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FACTORS AFFECTING THE PROPORTION OF ALATE AND APTEROUS FORMS OF APHIDS.

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INTRODUCTION.

This paper embodies the results of work done by the writer while pursuing graduate work at the Kansas State Agricultural College. Experiments on factors affecting wing-production in aphids were carried on from September, 1919, to March, 1920. A second series of experiments were conducted in December, 1921, and January, 1922. Considerable work was done while away from college in rearing, preparing and drawing specimens. Credit is due Dr. M. C. Tanquary, under whom the writer began the work, for suggesting the investigations and furnishing starting points; and to Dr. Tanquary, Dr. R. C. Smith and Prof. G. A. Dean for many helpful suggestions. The object of the experiment was to study the factors causing appearance of the different forms of aphids; to test conclusions reached by other workers; to look for any previously unsuspected factors; and endeavor, if possible, to formulate a theory which would account for all results.

Four explanations have recently been put forward to account for the appearance of winged and wingless forms of aphids. Ewing (6) found that temperature was an important factor, and that fewer winged aphids were produced at a moderate temperature than at higher or lower temperatures. Gregory (7) found that aphids which had been starved during development produced winged progeny, and that nutrition is a most important factor. Shull (18) pointed out that winged aphids pro-

duced a large number of apterous progeny, and wingless ones produced many alate progeny, and concluded that parentage was the dominant factor in wing-production. Work begun by Clarke (2), continued by Neills (11) and Woodworth (20), and elaborated by Shinji (16), showed that chemicals acting on the food-plant affected the parentage of winged aphids produced.

Six species have been reared in a preliminary way to test their suitability for this work. At the beginning, in September, 1919, four were reared; including a species common on corn and sorghum; one which had been previously reared on strawberry; one found on squash, which was neither of the aphid species common to that plant; and one abundant on wheat in the college greenhouses. None of these were then determined. The fourth species, since determined as *Rhopalosiphum prunifoliæ* Fitch, was soon recognized as best fitted for the work, and was used in all the experiments, the other species being discarded. In 1921 the pea aphis, *Illinoia* (*Macrosiphum*) *pisi* Kalt, then abundant on alfalfa, was reared for a time and found to be fairly well suited to experimental work of the sort the writer has attempted, except that it was very susceptible to disease. In January, 1922, a light green aphid species common to wheat was reared for a short time. It proved much less suitable than Rhopalosiphum. In all the experiments the aphids were reared on wheat, and in most cases in cages made by placing cloth-topped lantern globes or cotton-stoppered lamp chimneys over wheat plants growing in flower pots. Exceptions will be explained later. Transferring was usually done with a small brush. All were reared in constant-temperature chambers in the insectary except for a few kept under outdoor temperatures.

NOTES ON RHOPALOSIPHUM PRUNIFOLIÆ FITCH.

GENERAL NOTES.

The species of Rhopalosiphum used in 1919 and 1920 were identified by Dr. E. M. Patch, and those used in 1921 and 1922 by Dr. A. C. Baker. It has been commonly known as *Aphis avenæ* Fab., and in older literature as *Siphocoryne avenæ* Fab., but Patch and Baker state that the species was first correctly described as *prunifoliæ* by Fitch and that this name must hold. While it is sometimes classified as *Aphis prunifoliæ* Fitch, in Dr. Baker's new classification the species falls in the genus

Rhopalosiphum. The life history has been outlined by Pergande (13) and by Baker and Turner (1.) The species is widely distributed over the United States and the world. It is most common on wheat and oats, and on apple as a winter host, but occurs on a number of grains, grasses and other plants.

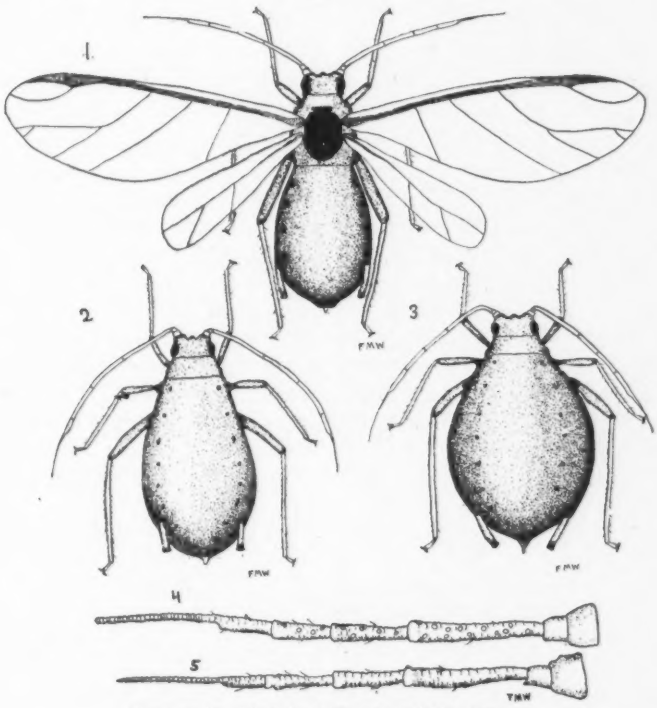

FIGURE I. *Rhopalosiphum prunifoliae* Fitch.

1—Winged adult, x 20. 2—Wingless adult, newly-matured, x 20. 3—Wingless adult, several days after maturity, x 20. 4—Antenna winged adult, x 50. 5—Antenna wingless adult, x 50.

The winged adult (Fig. I) is 1.6 to 1.8 mm. long, and 0.7 to 0.8 mm. in greatest width of body. The wingless adult is 1.8 to 1.9 mm. long and 0.8 to 0.9 mm. in greatest width. The newly born nymph is 0.7 to 0.9 mm. long and 0.3 to 0.4 mm. wide. The nymphs are light green at birth, their color deepening somewhat during growth. Reddish areas are found

about the base of the cornicles in both nymphs and wingless adults. These are characteristic of the species in its occurrence on grain. The winged adult is dark green, with no trace of red, and with black head, appendages and thoracic lobes. These descriptive notes apply to the summer forms, which are the most common of the forms in Kansas.

BIOLOGY.

Development from birth to maturity requires from 5 to 6 days at 80° F., and 6 to 7 days at 70° F. At higher temperatures the life cycle is not shortened, but is greatly lengthened at lower temperatures. Development ceases when temperatures fall below about 40° F. The four nymphal instars require respectively about 36 hours, 36 to 48 hours, 36 to 48 hours, and 24 to 36 hours, at 75° F. Females begin reproducing from a few hours to two days after the last molt. At ordinary temperatures the reproductive period lasts from 5 to 12 days and an adult may live several days later, so that females often live nearly a month. All periods are prolonged at low temperatures. Baker and Turner state that winged females require longer for development than wingless ones. This has been observed by the writer, especially in the later instars. With alate females a longer time usually elapses between the last molt and first young.

Early in the reproductive period the apterous females produce from 8 to 11 young a day and the total progeny may exceed 75, while with alate females from 6 to 9 young a day are often produced for a few days, and the total progeny may approach 50. In one typical set of experiments carried out after methods were well established and mortality low, the progeny of alate females averaged 19, and the progeny of apterous females 47.

A generation requires 5 to 7 days at 80° F., 7 or 8 days at 70° F., 10 days at 60°, and may require a month at an average temperature of 45° F. While the aphids can endure for a short time temperatures approaching 100° F., they die if such temperatures are maintained long, and do not thrive when the average temperature is above 80°.

While the males, oviparous females, and winter eggs occur in Kansas the species is evidently not dependent on them for hibernation. The summer forms have been found on grain

in this and neighboring states, during all the winter months. During two winters a few aphids have been kept alive in pot cages at outdoor temperatures until late in January. In one case a nymph survived a temperature of −16° F. It seems evident that the summer forms on grain commonly hibernate in Kansas. The males and oviparous females have not appeared in the winter colonies, under the influence of autumn cold, or of long rearing in a parthenogenetic line. In some cases apple cuttings were supplied, but the aphids refused to go to these, and when placed on them returned to wheat. The writer reared the species in one case 19 generations, in another 35, while Ewing (6) reared the same species 87 generations in a parthenogenetic line. It seems certain that under favorable conditions the species may continue indefinitely without appearance of the sexes.

DIVERGENCE IN DEVELOPMENT.

The divergence of apterous and alate forms during development is important from the standpoint of this paper. Differences develop both in form and color. This divergence is illustrated in Fig. II.

The nymphs destined to be alate are broader across the abdomen than those which will become apterous, and about the same width, if not a little narrower in other parts of the body. This gives them early in development a slightly pear-shaped appearance which is distinctive. The development of wing-pads in the later instars distinguishes them from apterous nymphs still more plainly. The two types of nymphs average about the same size throughout development, the alate nymphs being wider at the place of greatest width, owing to the shape of the abdomen, and usually a little longer. As maturity is approached the apterous forms attain the greater size.

The new born aphis is light green with reddish areas around the cornicles, and deepens in color with development. In the nymphs which will be apterous the green deepens slowly, and the red is blended with it. In those which will be alate the green deepens faster, especially in the region of the future thoracic lobes, and just posterior to it, and the reddish color contrasts with the green. After maturity the alate form does not change perceptibly in appearance, but in the apterous

aphid the color keeps on deepening, until in old wingless females the green has often deepened almost to black, and the red is obscured. The newly matured apterous aphid has the general appearance of a large nymph, but becomes broader and darker with age.

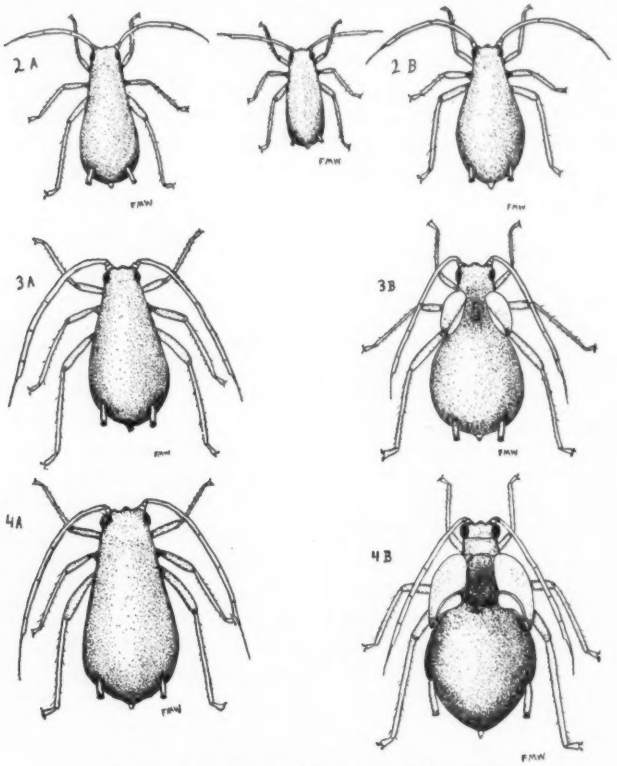

FIGURE II. *Rhopalosiphum prunifoliae* Fitch.

1—Nymph in first instar, x 20. 2A—Nymph in second instar, destined to become apterous, x 20. 2B—Nymph in second instar, destined to become alate, x 20. 3A—Nymph in third instar, destined to become apterous, x 20. 3B—Nymph in third instar, destined to become alate, x 20. 4A—Nymph in fourth instar, destined to become apterous, x 20. 4B—Nymph in fourth instar, destined to become alate, x 20.

In the first instar no difference appears. In many cases circumstances after birth may cause development in either direction. In others, previous circumstances have determined

the fate of the wings. In the second instar, while divergence is frequently noted, both in form and color, it can be detected only by an experienced worker. Experiments indicate that circumstances during this instar may still cause development or suppression of wings, in case their fate has not already been determined. In the third instar the wing pads appear, and in the fourth they become conspicuous. The other differences become accentuated and the alate nymphs are sharply differentiated from those destined to be wingless. All experiments seem to indicate that the fate of the wing pads is determined not later than the latter part of the second instar, and that after the second molt circumstances cause no change in the form of the aphid.

EFFECT OF PARENTAGE.

Shull (18), working with *Macrosiphum solanifoliæ* Ashm., showed the influence of parentage on aphid forms, and emphasized it in his conclusions. He found that the progeny of alate individuals were mostly apterous, and the progeny of apterous aphids included many alate. He also pointed out that winged males were the progeny of apterous mothers, and that wingless oviparous females were the offspring of alate females. From rearing records he traced a transition from preponderance of apterous to predominance of alate forms in the parthenogenetic phase of the cycle, and from predominance of males to predominance of females in the sexual phase. From these data he related the four forms to Riddle's theory of sex (15). He regarded the alate viviparous females and the males as forms of high metabolism and low energy content, and the apterous viviparous females and the oviparous females as forms of low metabolism and high energy content.

The influence of parentage was tested by the writer by rearing the progeny of numerous females, both alate and apterous, and recording the number of winged and wingless among the progeny. This work was all done in the temperature chambers, and as there were two of these, two sets were run at once. Thus the tests on the effect of parentage and the temperature formed a compound experiment. The Temperatures used are explained under "Effect of Temperature." The plan was to run 4 cages with each generation, as follows:

One with an apterous parent, the descendant of a line of apterous ancestors; one with an alate parent, the descendant of an alate line; one with an apterous parent, the progeny of an alate mother; one with an alate parent, the progeny of an apterous mother. It was found impossible, however, to maintain an alate line, though two consecutive alate generations were secured in several cases. The other three series were carried through as planned, and little difficulty was found in securing parents for the cages. One parent was used for each cage, and her entire progeny reared. At first it was necessary to move the parent to another cage as her oldest progeny neared maturity, since they would often begin reproducing before she ceased, and the small young would be confused. After a little practice, however, it was easily possible to detect whether a young aphid would be winged or wingless at least two days before maturity, by the presence or absence of wing-pads. The young were then removed and recorded before maturity. As will be set forth later, nutrition was found to be of extreme importance in wing-development. It was believed that the best way to keep nutrition uniform while testing other factors was to keep it near the optimum. The greatest care was exercised to keep the aphids well nourished. The chief difficulty was with plants occasionally failing to thrive, and poor condition of the food-plants was soon reflected in increased numbers of winged forms. These cases were few, however, and were encountered in each set of conditions. It was believed by using large numbers that this factor of variation was largely eliminated, and the results under different conditions were comparable. When it became apparent that plants were failing the aphids were transferred to better ones as soon as possible, and the effect was thus minimized. None were discarded on account of poor nutrition. It was found that very young wheat plants, 6 or 8 to a pot, were most suitable. These usually furnished an abundance of food for the family of an aphid of this species, and the aphids could easily be seen and counted by rotating the pot.

This compound experiment not only tested the factors of parentage and temperature, but also furnished aphids for parents, in experiments testing the factors of nutrition and the effect of chemical treatment. These experiments were checked by the temperature and parentage experiment.

The results of the compound experiment are shown in Table I.

TABLE I. RESULTS FROM GENERATION CAGES.

Temperature	Parentage	No. Families Reared	Progeny			
			Alate	Apterous	Total	% Alate
80° F.	Alate	10	2	83	85	2.35
	Apterous	20	21	243	264	7.95
	Total of both	30	23	326	349	6.59
75° F.	Alate	7	1	49	50	2.0
	Apterous	12	16	208	224	7.12
	Total of both	19	17	257	274	6.20
72° F.	Alate	13	2	224	226	0.88
	Apterous	20	65	864	929	6.99
	Total of both	33	67	1088	1155	5.80
70° F.	Alate	5	0	23	23	0
	Apterous	9	2	61	63	3.17
	Total of both	14	2	84	86	2.37
65° F.	Alate	10	4	140	144	2.77
	Apterous	19	7	693	700	1.00
	Total of both	29	11	833	844	1.30
*62° F.	Alate	15	19	191	210	9.05
	Apterous	23	61	249	310	19.67
	Total of both	38	80	440	520	15.19

* Approximate; see explanation under "Effect of Temperature."

TABLE II. DATA OF TABLE I ARRANGED TO SHOW INFLUENCE OF GRANDPARENTS.

Grandparent	Parent	Progeny at						
		80°	75°	72°	70°	65°	62°	Average of all Temperatures
Apterous	Apterous	147 9.73	158 3.79	700 9.22	35 5.71	440 1.15	153 24.84	1633 9.24
Alate	Apterous	117 5.98	66 15.15	229 0	28 0	260 .77	157 14.52	757 6.07
Apterous	Alate	71 2.82	50 2.00	195 1.02	23 0	144 2.77	169 11.24	652 2.28
Alate	Alate	14 0	....	31 0	....	....	41 0	86 0

(In each case the upper figure given is the total number of progeny reared, the lower figure the percentage of this number that were alate.)

A number of experiments were performed on the influence of nutrition. While these will be explained in more detail later, it is necessary to refer to them here in their connection with the percentage factor. In all these tests, which varied in nature, nutrition was limited in some manner, while in the parentage and temperature experiment, nutrition was near the optimum.

TABLE III. SHOWING INFLUENCE OF PARENTAGE AND NUTRITION.

Parentage	Parentage and Temperature Exper.		Nutrition Experiments		Total of Both	
	Total No.	% Alate	Total No.	% Alate	Total No.	% Alate
Alate	676	4.14%	165	9.09%	841	5.25%
Apterous	2552	9.17%	674	60.80%	3228	18.06%

"Total No." refers to progeny in each case.

From the above results the writer concludes that winged agamic females of this species have a strong tendency to produce all apterous progeny, and that wingless females produce a variable percentage of alate progeny. When other conditions are favorable for production of wingless aphids, the progeny of both forms will approach 100% apterous (as in well-nourished aphids at 65° F., Table I). When other conditions favor production of alate forms, the percentage of these in the progeny of winged mothers will show only a slight increase. In a similar case percentage alate in the progeny of apterous mothers will show a considerable increase, and may approach 100% (see Table III). When both mother and grandmother were alate, no alate progeny were produced. When both mother and grandmother were apterous the percentage of alate offspring was higher in most cases than where the grandmother was alate and the mother apterous. However, no difficulty was experienced in rearing 35 successive apterous generations, and no preponderance of alate forms was noted in the offspring at any time.

EFFECT OF TEMPERATURE.

Ewing (6), in rearing *Aphis avenæ* (a name by which *Rhopalosiphum prunifoliæ* has been commonly known, according to Baker and Patch) observed that no winged aphids developed at 65° F., few at 70°, about 80% were winged at 80°, and all became winged at 60°. He was working to find the effect of long-continued parthenogenesis, and the observations on effect of temperature were made incidentally.

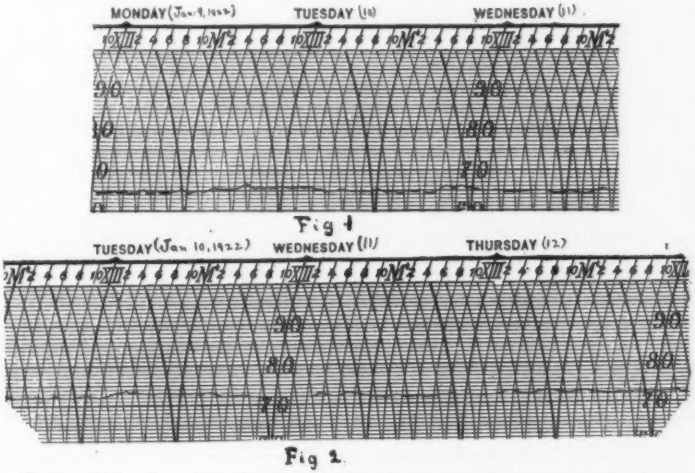

FIGURE III. 1 and 2—Facsimiles of typical temperature records taken during experiments.

In the writer's work the effects of temperature and parentage were made the subject of a compound experiment as described under the heading "Effect of Parentage." The rearing there explained was carried on in chambers, the air of which was conditioned by the apparatus described by Dean and Nabours (3). Since this article was written, a second chamber has been built, and the two can be kept at differing temperatures. The south chamber was kept at 80° from October 1, 1919, to January 15, 1920; at 75° from January 16 to February 23, 1920; and at 72° from December 21, 1921, to January 21, 1922. The north chamber was maintained at 70° from October 1, to March 20, 1919; at an average of 62° from November 21, 1919, to February 27, 1920; and at 65° from December 21, 1920, to January 21,

1922. The machine worked smoothly with few exceptions throughout the experiments, and wide fluctuations of temperatures seldom occurred. In the cases of all the temperatures except 62°, the temperature was near the desired point practically all the time, a straight line was sometimes described by the thermograph for several days, and the average was within a few tenths of a degree of the temperature sought. In the case of the average of 62°, it was attempted to maintain a temperature of 60°. This was found to be near the lower limit of the machine without special refrigeration, and with many warm sunny days, temperature often rose above 60°. Hence the air was allowed to become cooler than 60° at night. The average for the period was 62°. The fluctuations were wider than with the other temperatures and the minima were often below 60°. However, the results undoubtedly show the effect of temperatures lower than 65°. Duplicates of two representative temperature records are shown in Fig. III.

The results of the compound experiment are recorded in Table I. A condensation of Table I, showing the effect of temperature is shown in Table IV.

TABLE IV.

Temperature	% Progeny Alate		
	Of Alate Parents	Of Apterous Parents	Average of Both
80° F.	2.35	7.95	6.59
75° F.	2.0	7.12	6.20
72° F.	0.88	6.99	5.80
70° F.	0	3.17	2.37
65° F.	2.77	1.00	1.3
62° F.	9.05	19.67	15.19

The writer found that when other factors influencing wing-development were kept as nearly as constant as possible, the percentage of alate forms in the progeny of apterous parents dropped slowly from 80° to near 70°. In going lower the drop was more rapid, until at 65° the percentage was very low. At 62° the percentage of alate progeny showed a sharp increase.

In the progeny of alate parents, the percentage of alate was low and varied little at all the temperatures, except that at 62° a marked increase was shown. Since the progeny of apterous parents were more numerous than the progeny of alate parents, they have greater weight in the average of both.

No rearing in which all the progeny were counted was done at temperatures below 60°, but an apterous line was reared from March to December, 1921, 30 generations being produced. Average temperatures below 60° were experienced during several months, (55° in April, 59° in October, 44° in November and 36° in December) but no preponderance of alate offspring was noted and no difficulty was experienced at any time in maintaining an apterous line. Hence it seems unlikely that temperatures below 60° would show a considerable increase in the percentage of alate aphids, as might be deduced from the sharp increase in winged forms from 65° to 60°.

In Table V below, the writer's results are compared with Ewing's.

TABLE V.

Temperature	80° F.	75° F.	72° F.	70° F.	65° F.	60° F.*
Ewing's results, % Alate	80%	....	....	Few	0	100%
Writer's results, % Alate	6.59	6.20	5.80	2.37	1.3	15.19

* 60° in Ewing's experiments; average 62° in this work.

These results are seen to be parallel, though Ewing's percentages are much higher in three cases. In ordinary rearing, without careful attention to nutrition, a greater proportion of alate forms would occur than in the writer's experiments.

Nutrition is an important factor in wing-development in this species, and it was found necessary to control it carefully in order to test temperature. This is especially true because it proved to be a more potent factor than temperature in influencing wing-development. A comparison of the two factors, with explanation, will be found in Table X.

EFFECT OF NUTRITION.

Gregory (7) studied the effect of nutrition on wing-development in aphids. She used the pea aphis, called in her paper *Microsiphum destructor* Johnson. She starved the young during development, keeping them from food for periods of 8 to 24 hours at a time and a total of 40 to 60 hours during life. She found that few of the starved aphids developed wings; but when their young were reared, a large percentage became winged, even when well-nourished. However, when starved aphids became winged, their progeny contained few winged aphids. She concluded that starvation had little effect on the generation to which it was applied, but produced winged aphids in the succeeding generation.

In testing nutrition in this work the aphids were starved by confining them in small glass vials. The period of confinement was usually about 7½ hours each day. This was found to be the best length of time, as a longer period weakened the young aphids more than was desirable, and did not fit in with the other work. In one case, to be explained later, a 16 hour period daily was used. They were removed from the plants and replaced on them with a small brush. It was found that aphids must secure a firm footing on the plant when replaced. If they did not they would fail to establish themselves in their weakened condition, and few would survive. This was especially true of very young ones. Hence considerable time and careful work was required in the transfers, and, at the best, mortality was high. The young of winged parents proved more delicate under hardships than those of wingless parents, and a smaller proportion were successfully reared.

As it was found in several experiments that transfers did not affect wing-development, no special checks were employed in the nutrition experiments. The results from the temperature and parentage experiment were used to check these nutrition experiments. On account of the care and the numbers used, these results were more accurate than a special check could have been. Parents for the starvation experiments were taken from the progeny in the temperature and parentage experiment, hence their tendencies were known and readily checked from this experiment. At first it was attempted to use one parent in each nutrition experiment, but it was soon found better to use

several. They were placed on the plants and removed in a day or two, leaving a number of young, all of nearly the same age. It was soon noticed that a large percentage of aphids starved when developing became alate, especially if of apterous parentage. When this fact was established, some experiments were carried out to determine in what period of growth starvation was most effective in wing-development, and how many days of starvation were necessary to develop wings. These data are recorded in Table VI.

TABLE VI. EFFECT OF DIFFERENT PERIODS OF STARVATION.

Period Starved	Parent	Temperature	No. Tests	Progeny			Check % Alate
				Alate	Apterous	% Alate	
All through development	Apterous	80° F.	7	13	4	76.5	7.95
" " "	Apterous	70° F.	2	1	2	33.3	3.17
" " "	Apterous	62° F.	3	7	1	87.5	19.67
" " "	Alate	80° F.	3	1	4	6.7	2.35
" " "	Alate	75° F.	1	0	3	0	2.00
" " "	Alate	62° F.	3	1	5	2.00	9.05
First 4 days	Apterous	75° F.	1	1	7	12.5	7.12
" " "	Apterous	65° F.	1	0	9	0	1.00
" " "	Alate	75° F.	1	0	4	0	2.00
First 3 days	Apterous	80° F.	3	11	1	91.7	7.95
" " "	Apterous	65° F.	1	10	5	66.7	1.00
" " "	Apterous	62° F.	3	20	4	83.3	10.67
" " "	Alate	80° F.	3	0	9	0	2.35
" " "	Alate	62° F.	3	5	18	21.7	9.05
First 2 day	Apterous	75° F.	2	7	17	29.2	7.12
" " "	Apterous	72° F.	2	10	6	62.5	6.99
3rd and succeeding days	Apterous	75° F.	1	5	4	55.5	7.12
" " " "	Alate	75° F.	2	1	2	33.3	2.00
*4th and succeeding days	Apterous	80° F.	3	16	2	88.9	7.95
" " " "	Apterous	62° F.	3	7	1	87.5	19.67
" " " "	Alate	80° F.	3	4	16	20.0	2.35
" " " "	Alate	62° F.	3	1	7	12.5	9.05
2d day	Apterous	72° F.	1	0	11	0	6.99
2d and 3rd days	Apterous	72° F.	1	10	3	76.9	6.99
3rd and 4th days	Apterous	75° F.	2	6	7	46.1	7.12
*4th and 5th days	Apterous	75° F.	2	16	0	100.0	7.12
*4th day	Apterous	75° F.	1	3	3	50.0	7.12
2d and 3r dinstar	Apterous	72° F.	1	10	2	83.3	6.99
3rd and 4th instar	Apterous	72° F.	1	0	15	0	6.99

*The 4th day would usually include the latter part of the second instar, as the nymph would be about 72 hours old at the beginning of this instar.

In each case, the check from the corresponding parentage and temperature experiment is shown at the left. The young were starved about 7½ hours per day, except in the second of the two tests at 65°. In the first test with the ordinary starvation period no alate aphids were produced, although the effect showed in the progeny in the manner to be mentioned later. Hence in the second test a 16 hour period of starvation was used, and a high percentage of winged progeny produced, as shown in the table.

Starvation begun when aphids were about half grown caused many to become winged, but no evidence has been found that starvation begun after the second molt can cause development of wings.

In one case the soil of a cage was allowed to become dry, and of 20 aphids developing on plants thus deprived of moisture, 12, or 60% were winged, though the check was only 7% alate.

In a number of cases the aphids starved were retained until they produced young, and their young were reared. It was found that aphids which had been starved and had become alate produced nearly all apterous young, just as other alate parents, while aphids which had been starved, but remained apterous, invariably produced many alate young. This was true in all cases where starvation was applied, whether early or late in development. In some cases where the parent had been starved during only one or two days and remained apterous, most of the young were alate. In two cases adult apterous aphids were starved after maturity, having been well-nourished during development. In the first case one female, having been starved three days just after maturity, produced 18 young, of which 10, or 55%, were winged, the check being 7.12% alate. In the second case 3 females were starved during the three days after maturity, about 7½ hours a day as usual. The first day after starvation ceased, 19 young were produced, of which 18, or 94.7% were winged. The young for the next three days were discarded; the fourth day 15 young were produced, 11 or 73.3% being winged. The check was 6.99% alate. In all cases in which the young of starved parents were reared, these young were given ample nutrition. These data are summarized in Table VII.

TABLE VII. YOUNG OF STARVED PARENTS.

Parents (Starved during life)	Temperature	No. Tests	Progeny (well-nourished)			Check
			Alate	Apterous	% Alate	% Alate
Apterous	80° F.	5	12	27	30.8	7.95
"	75° F.	4	22	15	40.5	7.12
"	72° F.	5	79	13	85.9	6.99
"	65° F.	1	18	3	85.7	1.00
"	62° F.	3	6	5	55.5	19.67
Alate	80° F.	3	1	26	3.7	2.35
"	62° F.	1	0	16	0	9.05
Total Apterous		18	137	63	68.5	6.9
Total Alate		4	1	42	2.3	2.4

In cases where aphids were allowed to multiply for 2 or 3 generations, and overcrowded the plants of a cage, counts invariably showed high percentage of alate aphids. Some aphids were taken from such overcrowded plants, put on fresh plants, and their progeny reared with ample nutrition, with the results shown in Table VIII.

TABLE VIII. YOUNG OF OVERCROWDED PARENTS.

Parents (overcrowded during life)	Temperature	No. Tests	Progeny (not overcrowded)			Check
			Alate	Apterous	% Alate	% Alate
Apterous	80° F.	3	28	18	60.9	7.95
"	75° F.	1	6	1	85.7	7.12
"	62° F.	3	13	31	30.2	19.67
Alate	80° F.	3	1	26	3.7	2.35
"	62° F.	3	0	18	0	9.05

It was found, as might be expected from the data summarized in the last two tables, that poor nutrition showed its effect on one generation even after ample nutrition was supplied. In four of the temperatures used, in the generation and temperature experiment, the parents of the first generation were isolated from among poorly nourished aphids. The first generations results for these temperatures are not included in the totals of that experiment for this reason, but are given in Table IX for comparison and to show the effect of poor nutrition of parents.

TABLE IX. FIRST GENERATION RESULTS.

	80° F.		72° F.		70° F.		65° F.	
	No. Reared	% Alate	No. Reared	% Alate	No. Reared	% Alate	No. Reared	% Alate
First generation Apterous parent	17	70.6	61	34.4	0		32	53.1
Later generations Apterous parent		7.95		6.99		3.17		1.00
First generation Alate parent	13	7.7	4	75.0	14	7.1	19	5.2
Later generations Alate parent		2.35		2.0		0		2.77
First generation	30	43.3	65	36.9	14	7.1	51	35.3
Later generations		6.59		5.8		2.37		1.3
Both								

From the data cited a clear relation of the factors of nutrition and parentage as affecting wing-production can be traced.

No such relation can be found in comparing the factors nutrition and temperature. Scanty nutrition caused a high percentage of alate aphids at all temperatures at which it was tested. At 65°, as previously mentioned, starvation for the usual period did not cause the starved aphids to develop wings, but affected their progeny. When the length of the starvation period was increased a high percentage of winged aphids was produced at 65°. Table X shows the well-nourished aphids reared in the temperature and parentage experiment compared with those reared in the various nutrition experiments at similar temperatures. The latter were all limited in nutrition but at various stages for differing periods.

TABLE X.

Temperature	Generation Tests		Nutrition Tests	
	Total No.	% Alate	Total No.	% Alate
80°	349	6.59	220	39.5
75°	274	6.20	126	53.2
72°	1155	5.80	179	67.6
70°	86	2.37	3	33.3
65°	844	1.30	45	62.2
62°	520	15.19	166	36.1

(By "generation tests" is indicated the temperature and parentage experiment.)

The table illustrates how little the effect of temperature is shown under conditions of poor and varying nutrition, and suggests the importance of uniform nutrition in comparing temperatures.

It was found, in short, that limited nutrition early in life caused a large percentage of the progeny of apterous adults to become winged. The percentage of alate progeny was low with favorable nutrition. Of the young of alate parents few became winged even when starved. Aphids which had become winged under conditions of poor nutrition produced progeny which nearly all were wingless. Those which remained wingless in spite of such starvation during development produced progeny nearly all of which were winged, however well nourished. Apterous aphids starved after maturity also produced winged progeny. A high percentage of winged forms was produced by starvation at all temperatures tested, but greater difficulty was encountered in producing alate aphids at 65° than at other temperatures.

EFFECT OF CHEMICALS.

The fourth theory is that chemicals ingested affect development. Clarke (2) first demonstrated that young aphids feeding on cuttings with the lower end immersed in sand wet with a solution of a magnesium salt would develop wings. Woodworth (20) and Neills (11) continued this work, using *Nectarophora rosæ* L., as Clarke had done; Shinji (16) elaborated the work, using many compounds and several species of aphids. All the work was done with young aphids reared on cuttings, which were planted in washed sterile sand and watered with the solutions which it was desired to test. Among the substances found to be wing-producing were several magnesium salts, also silver nitrate, lead chloride, mercuric chloride, antimony chloride, silver sulphate and sucrose. Substances which did not develop wings were alcohol, acetic acid, tannin, urea, spring water, peptone, salts of alkali, and of earth metals, and alum. In general, the substances which did not develop an unusual percentage of winged forms are such as might occur in the soil, while those which produced winged forms are not usual soil constituents, or if present in quantity are toxic to plants. It was found that aphids which were not fed on the chemically charged cuttings until about half-way through

development would develop wings and that from 12 to 24 hours subjection to magnesium salts would cause wings to develop. A solution of magnesium sulphate as weak as $\frac{M}{1000}$ would produce the typical effect. Shinji minimized the effect of temperature on percentage of alate aphids developing, and suggested that the larger proportion of alate aphids observed on wilted plants may have been due to chemical changes in the sap obtained.

In this work it was first attempted to test the influence of chemicals by watering the soil of flower-pots in which wheat was growing with the solutions. In several tests this method failed to give results similar to Shinji's. The heavy metal salts used proved to be quite poisonous to the plants, stunning and nearly killing them, while the calcium and magnesium salts did not injure the plants noticeably. Later newly sprouted grains of wheat were planted in small jars in sterile sand, and watered with the solutions to be tested. With this method the sprouts failed to thrive in many cases, and the aphids made trouble by leaving the plants, so that few were reared.

The solutions were all $\frac{M}{10}$, except where the compounds were not soluble to that extent, when saturated solutions were used. Young were secured as in the nutrition tests, by placing several parents from the temperature and parentage experiments on the plants for a short time. The experiments with the first method were carried out at 80°, with the second method at 75° and 80°. The parentage and temperature experiment results at these temperatures furnished a check for them. A special check was also run for the second method. Table XI shows results for this method.

An effort was also made early in 1920 to rear aphids on wheat cuttings set in the solutions named. The cuttings died too soon for best results, few aphids were reared and no significant results were obtained. The heavy metal salts were very poisonous to the cuttings.

In 1921 and 1922 the time available was much shorter, and only magnesium sulphate was tested. This was done in two ways: aphids were reared on cuttings as before, and on seedlings growing in Pfeffer's solution, to which the magnesium salt had

TABLE XI. RESULTS OF CHEMICAL TESTS (1919–1920).

Chemical	Plants in Soil			Sprouts in Sand			Total	
	No. Tests	Alate	Apterous	No. Tests	Alate	Apterous	Alate	Apterous
H^2O (Check)	None			5	6	8	6	8
$ZnSO4$	4	11	23	5	0	2	16	25
$CuSO4$	4	5	23	5	7	26	12	49
$PbC_2H_3O_2)_2$	4	3	27	5	0	0	3	27
$Mg(NO_3)_2$	4	2	22	5	0	2	2	24
$Mg(NO_3)_2$ with excess of $Ca(NO_3)_2$	4	4	12	5	0	0	4	12
$MgCL_3$	4	7	13	5	8	19	15	32
$MgCl_2$ with excess of $CaCl_2$	4	6	5	5	14	16	20	21

(The numbers shown under "alate" and "apterous" are the number of aphids reared).

been added. In the latter case the wheat was sprouted in wet sand, washed, and transplanted into the bottles of Pfeffer's solution, in the manner described by McColloch (10). Magnesium sulphate was added to the solution in quantity sufficient to give a concentration of $\frac{M}{10}$ of this salt, while unmodified Pfeffer's solution was used in the check. Apterous aphids were placed on both, allowed to reproduce for a day or two, and their progeny reared. The cuttings used were stems of wheat about six weeks old. They were placed with the lower end of a $\frac{M}{10}$ magnesium sulphate solution, and others placed in tap water as a check. Apterous parents were supplied as with the plants in Pfeffer's solution. The young were transferred to plants in ordinary cages after living on the cuttings two days, as the cuttings did not last well. It was difficult to maintain good nutrition with this method. Table XII shows the results in 1921 and 1922.

TABLE XII. RESULTS WITH CHEMICALS IN 1921–1922.

Aphids Fed on	No. Tests	Aphids Produced			
		$MgSO_4$ Solution		Check	
		Alate	Apterous	Alate	Apterous
Plants in Pfeffer's Sol.	3	18	20	8	41
Cuttings in Water	2	15	6	9	9

The experiments were all carried on at 72%, and the results from the compound experiment at this temperature, with apterous parents, from an additional check.

The results obtained by Shinji and others with chemicals can evidently be duplicated with this species, though the wheat plant is by nature very difficult to use in such experiments. Plants rooted in soil or sand failed to give results similar to Shinji's. This was at first ascribed to selective absorption, and it was thought that rooted plants would not give the results secured with cuttings. However, magnesium sulphate has caused the development of winged aphids on rooted plants growing in Pfeffer's solution. The writer now believes the failures with plants in soil and sand, to be due to a fixing or adsorption of the chemicals by the soil. The Pfeffer's solution evidently permits the plants to take up enough chemical to affect the aphids.

In short, when wheat plants growing in Pfeffer's solution, and wheat cuttings in water were subjected to magnesium sulphate solution, a large proportion of young aphids of this species feeding on them became winged. Such results could not be produced when rooted plants in soil or sand were watered with solutions of magnesium salts or other toxic chemicals.

The writer believes the results secured by Shinji and others to be too abnormal to explain production of winged aphids in nature. Shinji stated a belief that the development of winged aphids on wilted plants commonly observed, was due to chemical changes in the plant sap. However, the writer obtained a large percentage of winged aphids on vigorous plants by removing them apart of each day during development. Changes in the sap would not be a factor in this case. The results with chemicals, however, are interesting in account of the striking

effect of the compound, because of the results with several species correspond closely, and because Shinji showed that the wing-developing factor was effective if applied when the aphids were nearly half-grown. The last two reasons are especially important from the standpoint of this paper.

OTHER OBSERVATIONS.

No other factors important in production of winged aphids have been observed by the writer. The accepted life-history of a number of aphid species indicate that many writers believed the cyclic factor important—that is, that numerous winged forms appeared in certain generations, counting from the stem mother. Haviland (8) after experimenting with other theories, concludes the cyclic factor to be one of the most important with the currant aphis (*Mysius ribis* L.). In the writer's work no results were obtained which would substantiate this view. Though individual families varied widely in proportion of alate aphids no connection with any given generation was traceable.

Baker (1) suggests that percentage of winged forms varies in different strains, and may be a heritable character. The two strains used by the writer at different times showed no perceptible difference. However, these were obtained from the same environment, and might have been identical. To test this factor, it would be desirable to have the aphids reproducing sexually, so that the origin of the strains, and their development from the first, could be observed.

It is interesting to compare different species of aphids with regard to the factors studied. The pea aphis, *Illinoia* (*Macrosiphum*) *pisi* Kalt, behaved similarly to *Rhopalosiphum prunifoliæ* with respect to parentage and nutrition, when observed in a preliminary way. Gregory also worked with the pea aphis; Shull with *Macrosiphum solanifoliæ;* and Ewing with the species used by the writer. Shinji secured closely corresponding results with several common species. The rather meager data so far secured indicates that the factors for wing-development work out in about the same manner in all the common species tested.

The writer has not been able to take up the factors influencing the development of males and oviparous females. As already stated, the sexes did not appear in these experiments under any conditions provided, though some have been seen in

the field. Shull (18) has indicated a belief that the sexes appear as part of a cycle. Phillips (14) has recorded valuable data on *Macrosiphum granarium* Kirby, stating that cold weather appeared to favor the development of the sexes, while high temperatures in the insectary prevented their appearance. Uichanco (19) believed that in the more primitive forms the sexes appear as part of a cycle, while in the specialized forms the development of the sexes is brought about by cold and in some cases by lack of food. In the rotifers which, like the aphids, reproduce both parthenogenetically and sexually, Shull (17) has worked out the factors bringing about the change from the first to the second method of reproduction. In this case, however, nutrition is the controlling factor, which is evidently not true with the aphids. With the species used by the writer, cold, hunger, or long-continued parthenogenesis did not produce the sexes and artificial colonization on the winter food-plant was ineffective. Just what combination of factors will produce the sexes is yet to be found. This subject has been even less studied than the production of winged forms.

SUMMARY.

Rhopalosiphum prunifoliæ Fitch, a species of aphid widely distributed on grain and well adapted for the work, was used in these experiments. Development occupies about 7 days, the total life nearly a month. From 25 to 75 young are usually produced by a female.

Parentage was tested by rearing the progeny of individuals, temperature by running these tests in two constant-temperature chambers, 80°, 75°, 72°, 70°, 65°, and 62° F. being tested. This formed a compound experiment. Nutrition was tested by starving young aphids and rearing them. Their progeny was sometimes reared also. Starvation was effected by confining the insects away from food a certain number of hours per day. The influence of chemicals was tested, by rearing aphids on both rooted plants and cuttings in the chemical solutions. Considerable difficulty was encountered in these tests. Wheat was used as a plant food in all cases.

Alate females produced all or nearly all apterous progeny; apterous females produced a greater or less proportion of alate progeny depending on other factors. The proportion of winged forms produced at 65° was lower than at either higher or lower

temperatures. A large proportion of aphids starved or overcrowded early in development became winged, as did the progeny of those remaining wingless in spite of poor nutrition. The progeny of alate aphids were usually apterous even when nutrition was poor. Greater difficulty was encountered in producing alate aphids by starvation at 65° than at other temperatures. Chemicals used tended to produce winged aphids in cases where the difficulty of the methods did not render a comparison impossible. Wing-production factors appear to be ineffective unless applied before the second molt. Other factors, such as the cyclic factor and the factor of varying strains, mentioned by some workers, were not apparent in these experiments. The writer was unable to produce the true sexes or find the factors causing their appearance.

The chemical factor, though interesting, appears to the writer to be too abnormal to be important in nature; the factors of nutrition, parentage and temperature are all important, and must all be considered in experiments planned to test any one of them. Definite relations exist between them in their effect on wing-development.

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THE GENUS PHILORNIS— A BIRD-INFESTING GROUP OF ANTHOMYIIDÆ

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The first contribution to a knowledge of this group was made by Macquart (1853, 657), when he described *Aricia pici* from Santo Domingo, recording the larva as a subcutaneous parasite of a woodpecker (*Picus striatus*), apparently a full grown bird.

Loew (1861, 41) next described *Hylemyia angustifrons* from Cuba, and Jaennicke (1867, 377) *Mesembrina anomala* from the same island, both without any data about larval habits.

Townsend (1895a, 79 and 1895b, 173) described a parasite of a nestling bird from Jamaica, under the name *Mydaea spermophilæ*, the host being Spermophila sp., probably *bicolor* Linn. The larva was under the skin of the nestling. Busck (1906, 2) furnished important additional information on *pici* from personal observations made in Santo Domingo. Some of his material is in the National Museum.

Macquart, Townsend and Busck all mention a cocoon made by the larva, which in normal conditions appears to be covered with grains of dirt.

The genus Philornis was erected by Meinert (1889, 304) with the single species *molesta*, new, known only in the larval state from nestling birds in Brazil, a subcutaneous parasite. Brauer and Bergenstamm (1894, 568) included the species in a list of parasitic Diptera, but added the unlucky suggestion "(Lucilia dispar?)." The latter fly belongs to the family Calliphoridæ. They erroneously gave as the host a European bird, which was mentioned by Meinert in a different connection.

Bezzi (1908, 545) followed the suggestion of Brauer and Bergenstamm and made Philornis a synonym of *Protocalliphora azurea*, the common European bird parasite, of which *Lucilia dispar* is also a synonym.

Neilsen (1911, 195) had received larvæ, puparia and adults of a nestling parasite from Concepcion, Argentina, which he

identified as *Mydaea anomala* Jaennicke; later (1913, 251) he received additional material in another species from Argentina, and on comparing the type of *anomala* found the latter to agree, so he gave the first species a new name, *torquans*. He figures the larval structures in both species.

Townsend (1919, 542) makes both Philornis and Protocalliphora synonyms of Phormia, continuing the mistake of Brauer and Bergenstamm.

Bezzi (1922, 29-46) gives an admirable summary of the literature of non-pupiparous Diptera infesting birds. In this paper he decides to accept Philornis provisionally as the valid generic name for the Anthomyiid group, including *Mydaea pici* Macquart, *torquans* Neilsen, and *spermophilæ* Townsend. He places *molesta* and *anomala* (of Neilsen, 1913) as synonyms of *pici*.

Malloch had the year before (1921, 41) proposed the genus Neomusca based on a cotype of *Mydaea obscura* Van der Wulp (Biologia, Dipt., II, 317, 1896), from Yucatan. He also had a specimen from Texas. No information was at that time available on the habits of the species, and Malloch did not connect it with the *pici* group. Recently, however, specimens of *obscura* were sent to the National Museum for identification by F. C. Bishopp, who reared them at Uvalde, Texas, from puparia found in the nest of the mockingbird. On comparison with undoubted *pici* from Santo Domingo in the National Museum, they were found to be congeneric according to the characters assigned by Malloch. The chief of these characters is the presence of a tuft of coarse hairs on the lower part of the declivity which lies between the root of the wing and the basal lateral angle of the scutellum, just above the line where the calypter joins the body; the genus is also distinguished by having the calcar wanting, pteropleura hairy, prosternum bare, arista long plumose and the third and fourth veins divergent, the latter a little bent forward at tip.

The question arises whether the genus Neomusca, based on good adult characters, should be displaced in favor of the older Philornis, based only on a few characters of the larva, but with its adult not certainly known. To answer this requires a consideration of all the facts at present known which serve to connect the two.

The principal character given by Meinert is the structure of the stigmal plate, or posterior spiracle, of the larva, which he figures (copied in my Fig. 1). This shows three simple slits in the shape of a U or V. Neilsen was fortunate enough to obtain larvæ, puparia, and adults of the two species in this group. In his two papers he figures the larval stigmal plates of both (*torquans*, adapted in my Fig. 2; and *anomala*, Fig. 3). *Torquans* has almost identically the same slits as *molesta*, but Neilsen (1911, 207) finds slight differences in the anterior spiracle and perhaps in the pharyngeal sclerites which seem to suggest a specific difference. *Anomala* has three slits, but they show

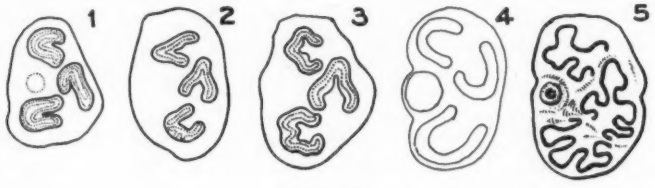

FIGURE I.

1. Philornis molesta Meinert, right stigmal-plate of third-stage larva. Copied from Meinert.
2. Philornis torquans Neilsen, same organ, copied without the shading from Neilson.
3. Philornis anomala Jaennicke, same organ, copied without the shading from Neilsen.
4. Philornis obscura Van der Wulp, right stigmal plate of puparium. Sketched by the author.
5. Philornis pici Macquart, right stigmal plate of puparium. All except No. 4 drawn by Chas. T. Greene.

traces of sinuosity and probably indicate another species. According to Neilsen's correspondent Mogensen *anomala* "before pupating made a cocoon of earth by means of a bright liquid which later on changed into a white substance." Torquans did not do this.

Returning to *obscura*, the type of Neomusca which infests the mockingbird in Texas, we were fortunate enough to get three puparia of Mr. Bishopp, from which he reared the flies. They agree with those of *torquans* in the stigmal plates (Fig. 4) except that the middle slit is almost reversed, and the upper and middle are more rounded. Here we are comparing the plates of a third-stage larva with those of a puparium, but we should expect little difference in these stages. Two of the *obscura*

puparia are enclosed in a dense mass or cocoon of downy feathers, indicating that pupation takes place in the nest, which is corroborated by Bishopp.

Our single puparium of *pici*, collected by Busck, has larger stigmal plates (Fig. 5) with decidedly sinuous slits; it resembles in this respect Neilsen's figure of *torquans*, but the slits are still more sinuous. In both this and the preceding, the posterior end of the puparium has a deep concavity, smooth inside, in which the stigmal plates are situated; and the same is mentioned by Neilsen for *torquans* and *anomala*, but he does not figure the plates. This concavity occurs also in the third-stage larva of *torquans*, according to Neilsen, but not in the earlier stages.

It thus appears, on comparison of the puparium of *obscura*, type species of the genus Neomusca, with puparia and larvæ of South American Anthomyiids that are almost certainly congeneric with *molesta*, type of Philornis, that in addition to similarity of habits there are structural characters which unite the species into a fairly homogeneous group that may well be assumed to be a single genus. I therefore conclude that Professor Bezzi's action is justified in adopting Philornis for the group; while Malloch is to be given credit for discovering new and valuable adult characters which define the genus, it would seem that his Neomusca is almost certainly a synonym of Philornis.

Stein (1918, 212) has redescribed the type of *anomala*, and has fortunately given enough characters to place it as a distinct species, not as formerly supposed a synonym of *pici*. However, when I asked Mr. Nathan Banks to compare Loew's type of *angustifrons* in the Museum of Comparative Zoology with the data in the present paper, he reported that it has the characters of *anomala*. Both species are described from Cuba and the synonymy may be regarded as fairly well established. I therefore use the older name *angustifrons*.

The distinction between *torquans* and *anomala* of Neilsen is very slight in adult characters; it seems to me that his first species, later called *torquans*, comes nearest to agreeing with Stein's description.

Spermophilæ was identified by Johnson from Jamaica (Bull. Amer. Mus. N. H., XLI, 1919, 440). He very kindly submitted his specimen, a female, for my examination. It is

not congeneric with the species under discussion, although it has several of the characters. It was not reared, and it has black palpi; I doubt if it be the true *spermophilæ*.

Omitting *torquans* and *spermophilæ* from further consideration for the present as unidentifiable without additional characters than those of the descriptions, the material in the National Museum falls into *pici*, *angustifrons* and *obscura*, which may be separated by the following table:

TABLE OF SPECIES.

Males.

Hind tibia on outer hind side with 3–4 short but stout spines near middle; front at narrowest .05 of head width, the median stripe almost or quite obliterated. *angustifrons* Loew.

Hind tibia on outer hind side with a single bristle at middle. Eyes contiguous; hind femur on outer lower edge with only small bristles except 2–3 near apex. *pici* Macquart.

Eyes separated, front at narrowest .09 to .11 the headwidth; hind femur on lower outer edge with a row of 8–9 stout spines, beginning near base..... *obscura* Van der Wulp.

Females.

Hind tibia on outer hind side with 3–4 short but stout spines (not seen)..... *angustifrons* Loew

Hind tibia on outer hind side with only one spine at middle. Abdomen subshining, with a faint bluish cast..... *pici* Macquart.

Abdomen opaque pollinose, with a trace of tesselation..... *obscura* Van der Wulp.

MATERIAL EXAMINED.

Philornis pici Macquart.

One female reared by Busck from *Dulus dominicus* in San Francisco Mts., Santo Domingo; puparium of same fly; piece of wing of same host bird, with hard swelling from which larva has emerged; one male, Higuito, Costa Rica (Pablo Schild); one female, Port of Spain, Trinidad, B. W. I., bred from larva on head of bird (Urich). I place the male here because Macquart's figure shows the eyes distinctly contiguous.

Philornis angustifrons Loew.

One male, Higuito, Costa Rica (Pablo Schild); one male, Berbice, British Guiana, 3–10–12, "bred from cutaneous tissue of a bird," "Twa-tina parasite." Through Robert Newstead. These agree well with Stein's description of *anomala*.

Philornis obscura Van der Wulp.

One male, two females, Uvalde, Texas, with three puparia, from nest of mockingbird (Bishopp, No. 6107); one male,

Chosica, Peru, 3000 ft., on foliage, IV–21–1914 (C. H. T. Townsend). The Texas male has the front .09 of the head-width, the Peruvian one is .11. One female has the legs dark just as described by Townsend for *spermophilæ*, which prevents me from recognizing the latter on leg color as Bezzi has done. The Texas material is identified by Malloch, but not directly compared with Van der Wulp's cotypes, which are now in the Illinois Natural History Survey Collection at Urbana, Illinois.

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THE GENUS PHLEPSIUS IN NORTH AMERICA (HOMOPTRA)

By Herbert Osborn and F. H. Lathrop.

The Genus Phlepsius was established by Fieber in 1866 and has as a haplotype the European species *intricatus*. It includes a rather small number of old world species but the number of American forms referred to the genus has been increasing rapidly until now there are more than 70 American species from North of Mexico and a number of species from Mexico, Central and South America.

A number of species have had general recognition although some have been referred to other genera. The first American form described was *irroratus* Say (1831) and except for a few species by Fitch (*fulvidorsum* 1851) Walker (*solidaginis* 1851) and Uhler (*excultus* 1877) but little attention was given to the group until the monograph of the genus by Van Duzee in 1892. In this paper Mr. Van Duzee gave a key to species, describing a number of new forms, making a total list of seventeen species. Of this original list *strobi* as identified by Van Duzee has been referred to *Eutettix* but *costomaculatus* has been included. Since Van Duzee's paper a number of species have been recognized and described by Osborn, Ball, Baker, Crumb, Sanders, DeLong and Lathrop. Inasmuch as this accumulation, with the widely scattered descriptions has made the identification of species difficult and several new species are in hand, making a total of over 80 species, it seems that a key to the known forms with diagnostic descriptions accompanied by outline figures of the genitalia will be useful in further work on the group. Undoubtedly additional species will be found upon careful collecting, particularly in localities as yet unworked and recognition of species will be facilitated by such a paper.

As originally established the genus character was based on the wide vertex and irrorate elytra. The type species possesses a distinctly sharp edged vertex, but evidently this character cannot be counted as of generic value since so many species

* Contribution from the Dept. of Zoology and Entomology, Ohio State University, No. 72.

which appear strictly cogeneric vary widely in the acuteness of the edge between the vertex and front. As limited in the present paper the genus includes forms having a single cross nervure, but with more or less distinctly marked irrorations or reticulations within the elytral cells. The vertex is flat or sloping, in a few instances upturned, without transverse furrow; front sloping, straight or convex in profile, sometimes concave on base and decidedly oblique to axis of body. The clypeus is usually more or less widened at apex and the loræ large, approaching margin of face. The elytra are longer than the abdomen, the wings generally fully developed and no species are as yet known of dimorphic short-winged forms. On the whole they are shorter and blunter than species of *Thamnotettix* or *Chlorotettix*. Structurally they resemble *Euscelis* but usually can be separated from this genus by the general fascies and the more oblique head with ocelli nearer the eyes.

Ball has published on Mexican and Central American species and proposed divisions to sub-genera. His basis of division is adopted in the main in our arrangement of species, but in order we have placed the *utahnus* group first, and *majestus* group last.

Most of the species are of grayish or brownish color, however, when a distinct color occurs this is quite constant. The more distinct specific characteristics are the shape of the vertex and the distribution of pigmentation of the elytra, but the most positive character is in the genitalia, both sexes ordinarily possessing a distinct genital structure. In general the size for each species is quite uniform. As a rule the males and females agree very closely in shape and markings and there is little difference in size, the males usually somewhat smaller. In the female the characters consist of distinct sculpturing of the last ventral abdominal segment. This varies greatly in details of hind margin. In the male the shape of the valve, but especially the outlines of plates afford reliable characters.

The genus is distributed in North America throughout the nearctic and in the neotropic region but the greatest known abundance occurs in the Mississippi Valley and it would seem that within this faunal area there has been the greatest opportunity for evolution of different forms. However, the Atlantic and Gulf Coast Region and the southwest states present a considerable array of species having limited distribution. A few

have a very wide distribution; *irroratus* occurs from Maine to Washington and south to the Gulf; *apertus* has a northern range from Atlantic coast to Rocky Mountains; *majestus* from New Jersey to Texas; *superbus* has a southern range from North Carolina to California. Most of the species, however, have limited range so far as determined and are adapted to certain ecological conditions or to restricted food plants. They may range from bogs of the northeast to arid plains of the southwest, but each species is adapted to distinct environmental conditions. In food plants they show wide choice, but most feed on grasses, or low herbs in fields, meadows and grassy plains. But very few have been studied for life history and there is large opportunity for careful work in determining details of habits, life history and ecology.

The authors have worked together on descriptive matter, the senior author especially on the key and technical descriptions and the junior author is especially responsible for the figures of the details for the species, which have been drawn to a common scale and as far as possible from type specimens and both descriptions and figures carefully compared and verified jointly. We have omitted all synonomy and bibliographic references except such as have appeared since the publication of Van Duzee's Catalogue. To have given them in such detail as to have been of value would have greatly extended this paper and it seems fair to assume that any one making use of this paper will have access to Van Duzee's indispensable catalogue.

MATERIAL AVAILABLE.

The materials examined include species collected for many years by the Senior author, collections in South Carolina and Oregon by the Junior author. Also collections from National Museum and Bureau of Entomology. These include many types of Osborn and Ball species as well as for species described by Ball, DeLong, Lathrop and Sanders and DeLong. We are especially indebted to Mr. E. P. Van Duzee, Dr. E. D. Ball, and Messrs. Sanders and DeLong for the opportunity to examine specimens in their collections, including much type material which has made possible the inclusion of many figures that would otherwise have been impossible. We are indebted to the South Carolina Experiment Station for the use of figures from Bull. 199 on Cicadellidæ of South Carolina by F. H. Lathrop.

KEY TO THE NORTH AMERICAN SPECIES OF PHLEPSIUS.

Pronotum with lateral margins very short, carina faint or obsolete....1
Pronotum with lateral margins distinct, carina well marked....10

1. Vertex angulate, elytra densely marked....2
Vertex rounded or faintly angulate, elytra sparsely obscurely marked....6
2. Markings varied with tawny and orange....*tinctorius*
Markings uniform gray, white and black or fuscous....3
3. Elytral pattern irregular....4
Elytral pattern uniform, with dense ramose lines....5
4. Small, vertex with minutely dotted picture....*utahnus and arizonus*
Larger, vertex with indefinite picture, oblique stripe on clavus..*pulchripennis*
5. Larger, length 4 to 4.5 mm. (Fla.)....*floridanus*
Smaller, 3.5 mm. (Me.)....*graniticus*
6. With distinct spots on elytra and in the costal cell....7
All spots on the elytra faint or obsolete....9
7. Vertex short, rounded....*costomaculatus*
Vertex longer, subangulate....8
8. Over 4 mm....*attractus*
Less then 4 mm....*loculatus*
9. With scattered small dots on vertex....*denudatus*
With star-shaped spots on vertex....*stellaris*
10. Carina on margin of pronotum very short, less than half short diameter of eye....11
Carina on margin of pronotum longer, more than half short diameter of eye, head narrower than pronotum....54
11. Front margin of head rounded or acute at apex only....12
Front margin of head thin, acute, front concave below vertex....46
12. Head rounded in front, not or very faintly angulate....13
Head angulate, vertex longer on middle than next the eye....29
13. Vertex very short, margins parallel or slightly longer at middle....14
Vertex perceptibly longer at middle than at eye....25
14. Margins of vertex very blunt, rounded or scarcely angled to front....15
Margins of vertex more angulate....16
15. Vertex short very sloping to front without ocellate spots....*latifrons*
Vertex less sloping, two ocellate spots on hind margin....*maculosus*
16. Costal cell without black spots....17
Costal cell with black spots....21
17. Small, 5 mm. long....*pusillus*
Larger, over 5 mm. long....18
18. Dark fuscous, 6 mm....*fuscipennis*
Light tawny....19
19. Over 6 mm., scutellum yellow, not concolorous....*tigrinus*
Scutellum concolorous tawny or brown....20
20. Vertex longer at middle than at eye, elytra with fine lines....*turpiculus*
Vertex scarcely longer, elytra minutely dotted....*micronotatus*
21. Elytra concolorous with head and pronotum....22
Elytra much darker than head and pronotum....*collitus*
22. Front black at base....*nigrifrons*
Front pale with broken black arcs....23
23. Larger, female 7.5 mm.–8 mm....*vanduzei, pallidus*
Smaller, length of female 7 mm. or less....24
24. Light gray, female 6.5 mm.; male 6 mm....*cinereus*
Dark gray. Female 7 mm.; male 6.25 mm....*cottoni*
25. Apex of vertex with dark spots....*lascivius*
Apex of vertex not marked with conspicuous black spots....26
26. Smaller....27
Larger....28
27. Vertex scarcely longer at middle than at eye....*altus*
Vertex nearly half longer at middle than at eye....*collinus*

28. Female segment long, deeply incised, male plates triangular.....*incisus*
Female segment short, four lobed, male plates spoon-shaped.....*tubus*
29. Not produced nor decidedly acute at apex of head.....30
Head decidedly produced at apex and acute, rounded toward ocelli.....43
30. Female ventral segment strongly dentate, male plates constricted at middle.....*irroratus*
Female segment not strongly dentate, male plates less constricted.....31
31. Vertex but little longer at middle than at eye.....32
Vertex distinctly longer at middle than at eye, sometimes twice as long....33
32. Female segment truncate.....*truncatus*
Female segment lobate at lateral angles.....*lobatus*
33. Elytra uniformly irrorate.....34
Elytra not uniformly irrorate, maculate over entire surface.....*maculellus*
34. A distinct white dot on one or both claval veins at tip.....35
White dot at end of claval veins faint or wanting.....40
35. Both claval veins with white dots at apex.....36
Hind claval vein only with conspicuous white dot at apex.....38
36. Vertex shorter, less angulate.....*tenessa*
Vertex longer, more angulate.....37
37. Larger, 7 to 8 mm.....*rileyi*
Smaller, 6 to 6.5 mm.....*torridus, brunneus*
38. Elytra not banded, irrorations fairly even.....*texanus*
Elytra more or less distinctly banded.....39
39. Vertex less angular (E. U. S.).....*apertus*
Vertex more angular, longer, (Pacific Coast).....*apertinus*
40. Head, pronotum and elytra uniformly colored.....*carolinus*
Head and pronotum much lighter colored than elytra.....42
41. Vertex nearly twice as long at middle as at eye.....*fulvidorsum*
Vertex less than twice as long at middle as at eye.....41
42. Elytra nearly uniformly dark.....brown, *particolor;* black, *eburneolus*
43. Elytra broadly banded; darker on posterior half.....*tullahomi*
Elytra with narrow distinct bands.....44
44. Head, pronotum and elytra nearly concolorous. *fastuosus, slossoni, lippulus*
Head and pronotum rufus or tawny, elytra gray.....45
45. Vetrex produced, half longer at middle.....*fulviceps, franconianus*
Vertex less produced, one-third longer at middle.....*strobi*
46. Apex of head produced and sharp edged.....*punctiscriptus*
Apex of head not specially produced but thin, sharp edged, the thin edge extending to near the ocelli.....47
47. Vertex very short with fore and hind margins parallel.....*planus*
Vertex longer, longer at middle than at eye.....48
48. Vertex not more than half longer at middle than at eye.....49
Vertex more than half, sometimes twice longer at middle than at eye.....50
49. Larger, 7 mm. or more.....*solidaginis*
Smaller, 6 mm. or less.....flecked with red, *josea;* without flecks, *nudus*
50. Larger, 9 mm. gray or light tawny.....*nebulosus*
Smaller, usually dark gray or fuscous.....51
51. Broad, with rather blunt-headed appearance.....52
More slender with more pointed head.....*occidentalis*
52. Vertex nearly twice as long at middle as at eye.....53
Vertex about one-half longer at middle than at eye.....*bifidus*
53. Vertex nearly flat.....*ramosus*
Vertex sharply upturned.....*tenuifrons*
54. Head wide, flattened, scarcely narrower than pronotum.....*extremus*
Head narrower, distinctly narrower than pronotum.....55
55. Front wider at base, vertex wider, head but little narrower than pronotum.....56
Front long and narrow, vertex narrow, head much narrower than pronotum..68
56. Sutural margin of elytra uniform without distinct light areas.....57
Sutural margin of elytra with distinct light areas.....63

57. Elytra uniformly and finely irrorate....58
Elytra coarsely reticulate or spotted....62
58. Length 7 mm. Female segment excavated to base (Mex.)....*eugeneus*
Length less than 7 mm. Female segment not excavated to base....59
59. More slender species....60
Robust species....61
60. Front with light arcs on dark ground....*superbus*
Front with dark arcs on light ground....*rufusculus*
61. Vertex short, but little longer at middle than at eye....*cumulatus*
Vertex longer, one-half longer at middle than at eye....*umbrosus*
62. Vertex depressed. Length 6 mm. (U. S.)....*areolatus*
Vertex convex. Length 6.75 (Mex.)....*mexicanus*
63. Vertex, pronotum and scutellum light, elytra dark....*excultus*
Vertex pronotum and scutellum concolorous with elytra....64
64. Elytra with coarse distant spots....65
Elytra finely and evenly irrorate....66
65. Elytra white coarsely spotted with black (N. C. to Fla.)....*distinctus*
Elytra pink, smaller, (Oregon)....*annulatus*
66. Vertex flat, or with depressed areas....67
Vertex convex, smaller species, elytra not flaring....*ovatus*
67. Vertex with distinct light line between ocelli. (Mex.)....*hosanus*
Vertex with less distinct line between ocelli, and the basal part more or less dotted. (U. S.)....*notatipes, graphicus, decorus*
68. Smaller species, 7.5 mm. or less....69
Larger species, 8.5 mm. or over....75
69. Larger, 7.5 mm., vertex banded....70
Smaller, 6 mm. or less, vertex not banded....71
70. Paler....*spatulatus*
Darker....*sabinus*
71. Elytral markings distinct, color....72
Elytral markings faint, color light ashy....74
72. Length 4 mm....*denticulus*
Length about 6 mm....73
73. Male pygofers twice as long as plates....*neomexicanus*
Male pygofers half longer than plates....*incurvatus*
74. Length 6 mm....*cinerosus*
Length 4 mm....*delicatus*
75. Vertex flat with a narrow light margin (Mex.)....*elongatus*
Vertex convex with a broad light margin....76
76. Vertex twice wider than long, female segment with a shallow notch....77
Vertex narrower, female segment with a deep narrow slit (Mex.)..*handlirschi*
77. Pale tawny, female segment with a shallow notch (Mex.)....*hebræus*
Dark tawny, female segment with a narrow notch, toothed, (U. S.)..*majestus*

NOTE.—Phlepsius *marmor, hemicolor* and *palustris*, described and figured by Sanders and DeLong, Proc. Ent. Soc. Wash., vol. 25, pp. 152-3, issued Nov. 26, 1923, are not included, as their publication came after our paper was in type. *Marmor* is near *graphicus* Ball, *hemicolor* near *fulvidorsum* and *palustris* seems to fall near *pianus*. *Phlepsius atropunctatus* DeLong, Hemip. Conn., p. 131 (1923), is *Fieberiella flori*, Stal. an European species evidently recently introduced, and taken also near Boston, Mass., and Rutherford, N. J. *Phlepsius dentatus* Baker is referred to *solidaginis* Walker.

Sub genus DIXIANUS Ball

Phlepsius tinctorius Sanders and DeLong. (Pl. XXV, Fig. 1).
Annals Ent. Soc. Am., Vol. XII, p. 235.

Head scarcely wider than pronotum, sub-angulate, vertex depressed on middle, nearly one-half longer at middle than next the eye, margin obtuse, front convex; pronotum with the lateral margins short, not carinate. ♀ ventral segment one-half longer than penultimate, simple and truncate behind, male valve small, angular, plates elongate triangular, compressed, not reaching tip of pygofer. Dark fulvous, vertex with the disk fulvous, anterior border and two spots on posterior margin yellowish, bordered with black. Pronotum fulvous with blackish irrorations, scutellum orange, with a black sutural spot, spots on lateral margin and apex ivory white. Elytra tawny or fulvous with whitish spots on discal and apical cells, veins and reticular lines black. Face black with small yellow dots. Length, ♀, 5.5 mm.; ♂, 5 mm.

New Jersey, on *Aralia spinosa*.

Phlepsius utahnus Ball. (Pl. XXV, Fig. 2).

Head distinctly wider than thorax; vertex narrow, one-half longer on middle than next eye, angulate, rounding to front, front in profile convex. ♀ segment short, truncate, slightly carinate, pygofers short and stout; ♂ valve long, roundingly pointed, the lateral margins concave at base, plates together equilaterally triangular, twice the length of the valve. Milky white, finely irrorate with dark fuscous. Front densely irrorate with dark fuscuous, without distinct arcs. Venation tawny, indistinct. Length, 4 mm.

Utah, Mexico.

Phlepsius arizonus, n. sp. (Plate XXV, Fig. 3).

Similar to *utahnus*, slightly larger; vertex shorter, more completely covered with dark spots; head distinctly wider than pronotum, sub-angulate; vertex wider than long, one-third longer at middle than at eye. Pronotum one-half longer than vertex, hind border nearly straight. ♀ segment short, scarcely longer than preceding; hind border faintly sinuate. A deep slit at middle reaching nearly to base. Gray; vertex pronotum and face densely irrorate with blackish; elytra closely inscribed with blackish ramose lines; legs annulate and spotted with black. Length, 4.25 mm.

Described from one specimen, (type), Osborn collection, Tempe, Arizona, 9, 26, '17, collected by H. L. Dozier.

Phlepsius pulchripennis Baker. (Fig. 1).

Head wider than pronotum; vertex angulate, one-third longer on middle than at eyes, rounding to the front; front convex in profile. ♀ segment, nearly twice as long as preceding, truncate; ♂ valve

triangular rounded behind; plates short, triangular, margins slightly concave. Gray and milky white, with fuscous and black lineations and spots. A black spot on clavus and four conspicuous black spots on costa. Length, ♀, 4.75–5 mm.; ♂, 4–4.25 mm.

Southern States.

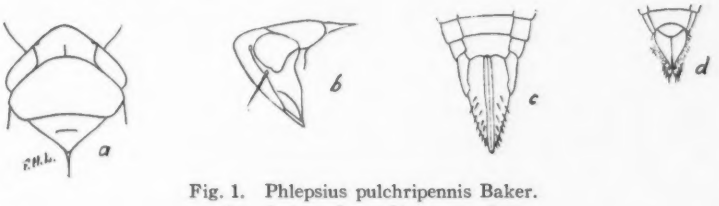


Fig. 1. Phlepsius pulchripennis Baker.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius floridanus Ball. (Pl. XXV, Fig. 4).

Resembling *irroratus* but smaller, form of *pulchripennis*, but with a longer vertex and about seven spots on the costa. ♀ segment rather long, rounding posteriorly with a pair of small rounding lobes on the median fourth.

What appears to be a male of this species has a broad, large valve nearly equalling the preceding segment in length; plates triangular, outer margins nearly straight, apices acute, about two and one-half times as long as valve. Length, ♀, 5 mm.; ♂, 4.5 mm.

Florida, South Carolina, North Carolina, Alabama.

Phlepsius graniticus n. sp. (Pl. XXV, Fig. 5).

Resembles *P. floridana* in size and shape, but has very distinct pigment lines; genital plates shorter. Head wider than pronotum. Vertex convex, subangulate, slightly longer on middle than next the eye, anterior edge obtuse. Front broad at base; ocellus close to the eye. Clypeus long, widening slightly to apex, loræ elongate. Cheeks sinuate below the eye, narrowed toward clypeus. Pronotum strongly arcuate in front, distinctly sinuate behind, lateral margins very short. ♂ valve broad and short, scarcely angulate behind; plates short, narrowing very abruptly from the bases, which scarcely reach the side margins of the valve, borders scarcely sinuate, black margined, lined with fine cilia. Dark gray, whitish, with deep fuscous dots and pigment lines. Vertex with two transverse fuscous spots between the eyes; front fuscous with minute dots and traces of arcs whitish. Elytra milky white, the veins and pigment lines blackish, a series of about 8 larger spots on costa. Length, ♂, 4 mm.

One specimen, Fryeburg, Me., collected by C. P. Alexander. This species cannot be associated with any other known form, although it has evident affinities with *P. floridana*. Type, Osborn collection.

Phlepsius costomaculatus Van D. (Pl. XXV, Fig. 6).

Head wider than pronotum; vertex roundingly subangulate, slightly longer on middle than against eyes, broadly rounding to front. ♀ segment about twice as long as preceding, nearly truncate. ♂ valve rather long, rounded; plates short, triangular outer margins straight, apex acute. Light gray with a distinct spot on the clavus, four black spots on the costa, pattern on elytra like *pulchripennis* but lighter. Length, 4 mm.

Texas, Mexico.

Phlepsius attractus Ball. (Pl. XXV, Fig. 7).

"Resembling *floridanus*, but with an evenly rounding vertex and a smaller number of spots on the costa." ♀ segment half longer than preceding, with border bisinuate. ♂ valve broad and short, bluntly rounding; plates small, margins slightly concave, their rounding apices upturned, about three times the length of the valve. Disc of the plates ivory white, polished. Length, ♀, 5 mm.; ♂, 4.25 mm.

Florida.

Phlepsius loculatus Ball. (Pl. XXV, Fig. 8).

Small; head wider than pronotum; vertex narrow, slightly longer than basal width, as long as pronotum, obtusely angled; apex bluntly rounded; front long, narrow; elytra long, narrow; venation as in costomaculatus. ♀ segment short, hind margin slightly notched at middle; pygofers long. ♂ valve triangular; plates together equilaterally triangular. Dark brown or black and white, ashy appearance; vertex white, sometimes suffused with yellow, with two pairs of brown dots on front margin near apex. Pronotum milky, with four broad mottled dark brown stripes; elytra milky with black markings similar to *costomaculatus*. Length, 3 to 3.5 mm.

Utah and California.

Phlepsius denudatus Ball. (Pl. XXVI, Fig. 1).

Almost white, very pallid, irrorations almost obsolete. Head wider than thorax; vertex one-third longer on middle than next eye, rounding to front; front convex in profile. ♀ segment about twice as long as the penultimate, the lateral angles feebly, angularly produced, the margin between them very slightly rounding with a small semicircular median emargination. ♂ valve small, short, broad, rounded behind, plates broad, triangular, together forming a nearly equilateral triangle. Whitish with obscure irrorations, vertex with broken black spots near anterior border, black behind eyes on pronotum, triangular black spots on basal angles of scutellum and a smaller pair on the disc; front with faint brownish arcs. Length, 4.5 mm.

S. W. New Mexico, Arizona, S. California.

Phlepsius stellaris Ball. (Pl. XXVI, Fig. 2).

Similar to *loculatus* in structure, and *denudatus* in color. Head broad; vertex short, obtusely rounded; scarcely longer at middle than next the eye; front short; elytra long, narrow; venation obscure. ♀ segment broad, short, almost parallel with margin, with a slight median notch. Creamy white; ocelli and four equidistant dots on vertex margins between these dark, a pair of irregular star-shaped spots on anterior disk of vertex; one ray of each star including the outer margin spot on either side, and another touching the eye; elytra creamy; nervures faintly fulvous; face and below creamy; with brown arcs on either side of the front between the antennal sockets, attached to a brown cloud in center forming a spider like marking on face. Length, 4 mm.

St. George, Utah.

Sub genus PHLEPSIUS Fieb.

Phlepsius latifrons Van D. (Pl. XXVI, Fig. 3).

Head wider than pronotum, vertex short, evenly rounding, scarcely longer on middle than against eye, front in profile convex. ♀ segment very long, deeply notched on middle, lateral lobes slightly reflexed, tips edged with black. Dark gray, coarsely irrorate with dark fuscous; vertex creamy with dark brown irrorations arranged in clouds on each side of middle; front mottled with whitish, with about four indistinct arcs on each side. Length, 7 mm.

Tennessee, North Carolina, Georgia, Florida.

Phlepsius maculosus Osborn. (Pl. XXIII, Fig. 1).

Phlepsius maculatus Osb. (Pre-occupied), Ohio Nat., Vol. V, p. 276, 1905.

Large, coarsely maculate; head equalling pronotum in width, vertex short, scarcely longer on middle than next eye, rounding to front; slightly more acute at apex, front in profile distinctly convex. ♀ segment two and one-half times as long as preceding, narrowing to hind border, produced medially with a central black disc, polished black either side the median line. Milky white with dark irrorations blending into maculations on head, pronotum and elytra. Four dark spots on anterior margin of vertex, two rounded blackish spots, including whitish pupil, next hind border. Length, 7 mm.

One specimen from Sandusky, Ohio, (Type in Osborn Coll.) Also taken in New York (Olsen).

Phlepsius pusillus Baker. (Pl. XXVI, Fig. 4).

Head broad, wider than thorax; vertex broad, slightly longer on middle than against eye, evenly rounding, rounding to front; front in profile convex. ♀ segment twice as long as preceding, posterior angle lobate, median part truncate or slightly produced, a distinct median carina, on each side of which is a dark point. ♂ valve short, angulate behind, plates about 3 times as long as valve, narrowing to behind

center, extending into acute points. Brown with fine irrorations; vertex with two white spots near hind border, ocelli margined with white, front with fragments of a few arcs, elytra with milk-white patches. Length, 4.75 mm.

Described from Maryland. Redescribed from specimen from Washington, D. C.

Phlepsius fuscipennus Van D. (Fig. 2).

Head slightly wider than pronotum, scarcely angulate, short; vertex slightly longer at middle than next the eye; front broad. Pronotum short, slightly concave behind; elytra narrow and flaring toward tip. ♀ segment one-half longer than preceding; hind border bisinuate, a rather broad lobe at center margined with black. ♂ valve long, angulate, rounded at tip; plates broad at base, sides concave, tip acute. Dark brown to fuscous, uniform above, closely irrorate; elytra sometimes with darker spots. Length, ♀ 6 mm.; ♂ 5.25 mm.

Eastern United States, New York to Florida; west to Illinois, Kansas and Louisiana.

Fig. 2. Phlepsius fuscipennis VanD.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius tigrinus Ball. (Pl. XXVI, Fig. 5).

Head wider than pronotum; vertex short, scarcely longer on middle than next eyes; sloping, rounded at front. Front in profile convex, broad at base, narrowing to clypeus. ♀ segment twice as long as preceding, posterior margin slightly emarginate, middle third weakly produced and dark margined. ♂ valve triangular, plates narrowing to rounded tips. Tawny brown, reticulations faint; scutellum light yellow, basal angles tawny; front with arcs very faintly indicated. Length, 6 mm.

Cantwell Cliff, Ohio. In Pine Association. Described from Washington, D. C.

Phlepsius turpiculus Ball. (Pl. XXVI, Fig. 6).

Head as wide as pronotum, vertex but little longer at middle than next the eye, margin roundingly angulate, front broad above, subangulate at antennæ, narrowing sharply to clypeus, which is narrowed

near its base. ♀ segment twice as long as penultimate, with a slight notch at middle, sinuated each side, lateral angles rectangular. ♂ valve triangular, margins indented midway to apex; plates narrowed to near middle then tapering to acute tips, similar to ***irroratus***. Dull creamy white, rather minutely irrorate with brownish or fulvous, a lighter tip and crescent on the vertex and faint arcs on the front. Length, ♀ 7 mm.; ♂ 6 mm.

Originally described from Holly and Ft. Collins, Colo., and Stratton, Neb., and with later records from Ontario and New York. We have specimens referred to this species which extend its range to Hodgman Co., Kans. (Lawson), Olivia and Brownsville, Tex., (H. O.), Shreveport, La., (Mally), Langdon, Mo., Chicago, Ill. (J. G. S.), Union Pt., Ga., and Columbia Orangeburg, Yemassee and Charleston, S. C. (F. H. L.), Bay Pt., Marblehead, Ohio (H. O.).

Phlepsius micronotatus n. sp. (Pl. XXIII, Fig. 3).

Somewhat like turpiculus but with the elytral reticular pigmentation in minute dots; a double black spot on base of front, barely showing above. Head slightly broader than thorax, broadly rounded, scarcely angulate. Vertex scarcely longer on middle than next the eye, margin obtuse; front broad, narrowing uniformly from antennæ to clypeus; loræ broad; cheeks sinuate below the eye. Pronotum short, nearly semicircularly arched in front; posterior border distinctly concave. Elytral venation rather faint, mostly obscured by the minute pigment granules. ♀ segment about twice as long as preceding, posterior border sinuate, median third slightly produced, notched on middle with a bifid black spot, lateral angles distinct. ♂ valve short, broad, obtusely angulate behind; plates narrowing uniformly to rather blunt divergent tips, lateral margins slightly concave, set with six short spines on dark dots. Gray, faintly suffused with tawny or yellowish. Vertex light yellowish minutely dotted with fuscous. Pronotum and scutellum minutely irrorate. Elytra dull whitish, densely covered with minute dots, leaving occasional open spaces. Front whitish, minutely dotted with fuscous, arcs faintly indicated. Length, ♀ 7 mm.; ♂ 6.5 mm.

Described from three females and four males. Guadalajara, Mexico, Aug. 12, 1903. Type and paratypes, Osborn Coll.

Phlepsius collitus Ball. (Fig. 3).

Head as wide as pronotum, vertex scarcely longer at middle than next the eye, anterior edge angled. ♀ segment twice as long as penultimate, faintly notched at middle, either side of which there is a distinct sinus, the borders of which are blackened. ♂ valve broadly triangular, plates broad, short, margins scarcely sinuate. Vertex, pronotum and scutellum ivory white, contrasting with the darker elytra which are

densely reticulate with fuscous, and with obscure whitish bands at middle and end of clavus. Face fuscous mottled with whitish and with pale arcs on the front. Length, ♀ 6 mm.; ♂ 5.75 mm.

From Maine to Florida and west to Iowa. In meadows. A pale variety has been taken at Buckeye Lake, Ohio.

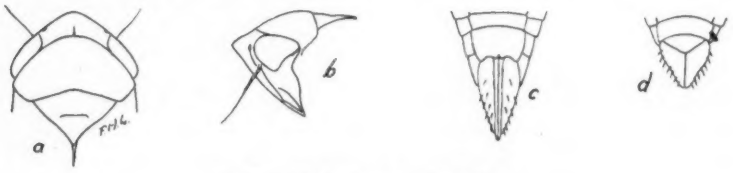


Fig. 3. Phlepsius collitus Ball.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius vanduzei Ball. (Pl. XXVII, Fig. 1).

A large species of the form of *cinereus*, gray cinereus with a trilobate commisural line; vertex bluntly conical, one-fourth longer at middle than at eye, rounded to front; front short; clypeus long, wedge-shaped, broadest at apex; elytra broad, flaring at apex. ♀ segment interrupted, appearing as a narrow strip either side, within which is a thin membrane shaped much as apertus. ♂, valve triangular; apex obtusely angular; plates broad at base, roundingly triangular; apices depressed and slightly divergent. Dull whitish, sometimes washed with yellow on vertex and pronotum; vertex with a round black spot either side at base. Pronotum and scutellum faintly marked; elytral veins yellow and fuscous; areoles finely, sparsely marked with ramose lines. Length, 8 mm.; width, 2.75 mm.

Described from Rifle, Colo. Type in Ball Collection.

Phlepsius nigrifrons Ball. (Pl. XXVII, Fig. 2).

Head wider than pronotum; vertex short, slightly longer at middle than next the eye; front full, broad at base; elytra broad, compressed behind, resembling *vanduzei*, but with apical cells short. ♀ segment wanting or appearing as a pair of widely separated rectangular plates, a pair of roundingly pointed plates overlap these on their inner margins, leaving the median fourth exposed. Male valve rounding, with the apex bluntly produced; plates together nearly semicircular, with the apices bent up and slightly produced. Vertex pale yellow in female, a pair of brown spots at base and a small pair just back of apex, black. The black of front is visible from above, either side of apex. In the male an arch of irregular dots connect the basal spots. Two or three dots inside ocelli and the frontal markings extend up to the apical spot; front black at base with faint light arcs. Pronotum, scutellum and elytra pale with fuscous irrorations and lines; an interrupted black stripe from base beneath claval suture to first cross-nervure then becoming indistinct. Length, 7 mm.

Arkansas. Known only from type specimen in Ball collection.

Phlepsius pallidus Van Duzee.

Similar to *cinereus;* larger. Head a little wider than pronotum; vertex short, rounded to front. Pronotum nearly flat, nearly two and one-half times as long as vertex. ♀ segment long, obtusely sub-triangular; apex broad, emarginate, sides interrupted by small lobate lateral angles. Pale cinereus, tinged with fulvous beneath and on disk of pronotum; pronotal irrorations irregular in front, leaving four to six white spots; elytra white with a narrow sub-basal band and about three coalescing bands beyond middle, forming an obscure w, pale fulvous. Length, 7.5 mm.

Texas.

Phlepsius cinereus Van D. (Pl. XXVI, Fig. 7).

Phlepsius optatus Crumb. Ann. Ent. Soc. Am., Vol. VIII, p. 194, (1915).

Head scarcely wider than pronotum, vertex rounding scarcely angulate, scarcely longer on middle than next eye, margin obtusely angulate front convex. ♀ segment twice length of preceding, ridged and elevated, posterior margin nearly truncate, lateral angles rectangular, two black points either side of a median notch. ♂ valve short, broadly rounded, plates narrow, bases scarcely broader than valve, tapering to bluntly rounded tips, exceeding pygofer. Light gray. Milky whitish with fuscous irrorations and lines and a distinct blackish spot at end of claval vein. Length, ♀, 6 mm.; ♂, 5 mm.

Described from Texas and now known from Iowa, Kansas, Florida, Mississippi, Louisiana, Ohio, North Carolina.

Optatus Crumb seems to merge into *cinereus* when any large number of specimens are compared and we have concluded that it must be placed as a synonym.

Phlepsius cottoni, Sanders & DeLong, (Pl. XXVII, Fig. 3).

Proc. Ent. Soc. Wash., Vol. XXIV, p. 98, 1922.

Head blunt, short; vertex margins nearly parallel, a trifle longer on middle than next the eye. Pronotum more than twice as long as vertex; elytra broad, tips flaring. ♀ segment "twice as long as preceding. Side margins abruptly narrowed about one-third the distance to apex, then convexly produced to posterior margin, which is slightly sinuated forming four indistinct lobes, a small one at either side and two larger ones at middle, the latter two separated by a rather broad, shallow notch." ♂ valve triangular, almost equilateral, longer than last ventral segment; plates divergent, produced the length of valve beyond its apex, outer margins at base almost straight then abruptly narrowed at two-thirds their length to the robust, parallel margined and bluntly rounded apices. Vertex, pronotum, scutellum and face white, rather heavily but irregularly irrorate with brown. Scutellum more heavily marked, with three conspicuous white spots, one at apex and one midway

on either side. Elytra white, rather sparsely and irregularly inscribed with brown. Posterior half more heavily inscribed, apex and spots along costa dark brown.

Described from Florida. Specimens from Raleigh, N. C. July, 1919, (Osborn and Metcalf).

Phlepsius lascivius Ball. (Pl. XXVII, Fig. 4).

Head scarcely wider than pronotum, vertex slightly longer on middle than next to eye, rounding to front; front in profile convex. ♀ segment very long, hind margin truncate, middle third slightly produced, with a median notch. ♂ valve broad, obtusely angulate behind; plates broad to base, narrowing rather uniformly, distinctly divergent. Yellowish white with brownish fuscous irrorations, vertex white at tip with polished black spot on each side, a few indistinct arcs on front. Length, 6 mm.

Holly, Pueblo, Ft. Collins, Colorado; Kimball, Nebraska, (Ball); also Devil's Lake, N. D. (H. O.); Kalispell, Mont. (H. O.); Lewis Springs, Arizona, (H. M.).

Phlepsius collinus n. sp. (Pl. XXVII, Fig. 6).

A small, dark, rather broad species, with head broader than pronotum, and general appearance somewhat similar to *altus*, but with distinct genitalia. Head slightly wider than pronotum, distinctly angulate. Vertex rather narrow, about twice as wide as long, nearly half longer on middle than against eye, distinctly angled to front; front broad and short, narrowed abruptly from antennal sockets to clypeus; clypeus long, over twice its basal width; lora large, nearly half the width of the cheek; margin of cheek sinuate. Pronotum short, more than twice wider than long, broadly arcuate in front, nearly twice length of vertex, scarcely concave behind, lateral margins short, carina very short but distinct. Claval veins approaching each other near the middle. Elytra but little exceeding the abdomen. ♀ segment twice as long as penultimate; hind border slightly produced, notched on middle; lateral lobes rounded, median apical third polished black. ♂ valve broad, obtusely angulate behind; plates short, abruptly narrowed to the rounded, closely attigent tips. Apical part of valve and median part of plates lighter, margin dusky, with a few short, whitish hairs. Dark gray to fuscous. Vertex, pronotum and scutellum dark fuscous, faintly irrorate with whitish dots. Elytra milky white with dark brown veins and blackish lines and dots. Face dark fuscous minutely dotted with yellowish. Abdomen beneath dark fuscous. The whole insect with a faint metallic lustre. Length, ♀, 5 mm.; ♂, 4.5 mm.

Anacostia D. C. (J. G. Sanders). Type, (Osborn collection.)

Also collected in grass in a wash or gully, on a hillside, at State Experiment Farm, Swannanoa, N. C., August 22, 1919.

Phlepsius altus O. & B. (Pl. XXVII, Fig. 5).

Small, ovate, head slightly wider than pronotum, vertex short, about one-fifth longer on middle than next eye, bluntly angulate to front; front in profile convex. ♀ segment with the lateral angles extended into blunt lobes; between these the margin is transverse and black marked. ♂ valve rather large, triangular, plates short, about twice as long as valve, narrowing uniformly to subacute tip. Grayish white, minutely and rather regularly irrorate with fuscous dots and lines, ocelli circled with whitish; front with faint indications of arcs. Length, 5 mm.

Western prairies and plains, on grass. Also recorded for New Jersey, Maryland, Florida (V. D.) but these records may include *collinus*.

Phlepsius incisus Van D. (Pl. XXVIII, Fig. 1).

Head scarcely wider than pronotum; vertex short, angulate, slightly longer on middle than against eye, distinctly angled with front, front convex in profile. ♀ segment elongate, narrowed behind, notched on middle, outer border of lateral lobes edged with black. ♂ valve broad, obtusely angulate behind; plates two and one-half times as long as valve, margin sinuate, apex roundingly acute. Grayish, irrorate with tawny and fuscous; vertex with broken ivory white line on anterior margin, front with three or four arcs and a few distinct light points near the base. Length, 6 mm.

Massachusetts, Ohio, New York, Pennsylvania, Michigan, Tennessee.

Phlepsius tubus Ball. (Pl. XXVIII, Fig. 2).

Similar to *fuscipennis*. Head wider than pronotum; vertex narrow, rounded to front, slightly produced at tip; front broad, short, elytra broad, slightly flaring. ♀ segment broad, short, hind margin with four rounded lobes, the middle pair slightly broader than the lateral ones, black margined. ♂ valve long, triangular; plates short, rugose at base, bluntly spoon-shaped at tip. Vertex, pronotum and scutellum fulvous-brown, irrorate with yellowish; elytra finely reticulate with ivory-white; veins tawny. Length, 5.25 to 5.75 mm.

District Columbia, North Carolina and Alabama.

Phlepsius irroratus Say. (Fig. 4).

Head slightly wider than pronotum; vertex obtusely angulate, about one-fourth longer at middle than next the eye; margin nearly right-angled with front. Elytra long, narrowed toward tip. ♀ segment deeply notched each side of an acute central tooth, lateral lobes rectangular, their inner part blackish, a median carina and a faint carina on each side extending to the tip of the lateral lobes. ♂ large, broad;

plates abruptly narrowed to before the middle, then narrow strap-like, bluntly pointed and reaching tip of pygofer. Dull yellowish with fuscous irrorations on head and pronotum and ramose lines on elytra. Length, ♀, 6 mm.; ♂, 5.5 mm.

Widely distributed from Atlantic to Pacific and Canada to gulf. Especially common in meadows and pastures and of economic importance. (See Osborn Bull. 108, Bur. Ent., U. S. Dept. Ag.).

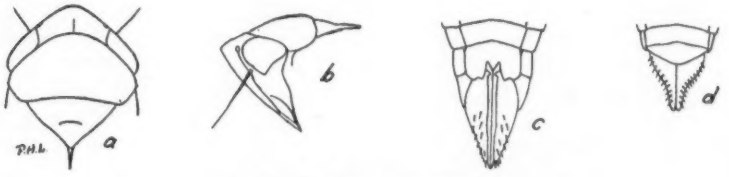


Fig. 4. Phlepsius irroratus Say.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius truncatus Van Duzee. (Pl. XXVIII, Fig. 3).

Resembles *irroratus* but with entirely different genitalia. Head slightly wider than pronotum, vertex obtusely angulate, about one-fourth longer at middle than next the eye. ♀ segment twice as long as penultimate, raised on the disk, central part truncate at tip, the lateral portions slightly convex, rounded at the angles. ♂ valve broad, short, scarcely angulate; plates elongate triangular, acute at tip. Dark gray, fuscous irrorations and pigment lines on whitish ground. Length, ♀, 5.5 mm.; ♂, 5.25 mm.

Pennsylvania to Florida and west to Iowa.

Phlepsius lobatus Osborn. (Pl. XXIV, Fig. 1).

Head slightly wider than pronotum; vertex subangulate, slightly longer at middle than next the eye. ♀ segment rounded at middle with a median and lateral carina, lateral angles produced into prominent lobes. ♂ valve short, rounded behind; plates short, broad at base, narrowing abruptly to blunt tips. Vertex dirty yellowish, with fine irrorations. Front minutely irrorate, with a pair of oblique spots and four arcs. Elytra whitish with brown and fuscous dots and lines. Length, ♀, 5 to 5.25 mm.; ♂, 4.5 mm.

Iowa, Wisconsin, Kansas.

Phlepsius maculellus Osborn. (Pl. XXVIII, Fig. 4).

Head wider than pronotum, subangulate, vertex about one-fourth longer on middle than next eye, rounding to front; front in profile convex. ♀ segment long, about twice length of preceding, lateral angles produced in short rather acute lobes, hind border nearly straight

elevated, notched at middle, broadly bordered with black. ♂ valve triangular, obtusely angled behind, plates short, broad at base, narrowing abruptly to obtuse tips, about one and one-half times as long as valve. Ochraceous; elytra coarsely maculate with blackish irrorations, leaving quite distinct areas of milky white, vertex with two rather distinct roundish spots near hind border, front coarsely irrorate, without distinct arcs. Length, ♀, 6 mm; ♂, 5.5 mm.

One specimen Orono, Maine, August 5th, (Type, Osborn Col.), one Cranberry Lake, N. Y., (C. J. D.) Aug. 10, 1917, and both sexes Cranberry Lake, Aug. 11–12, 1920. (Osborn and Drake).

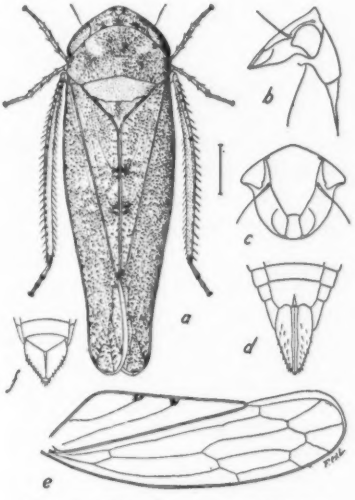


Fig. 5. Phlepsius tenessa DeLong. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron; *f*, ♂.

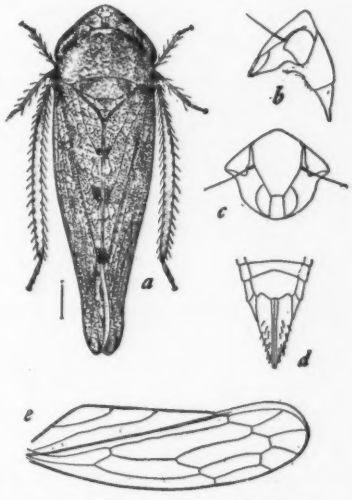


Fig. 6. Phlepsius torridus Lathrop. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron.

Phlepsius tenessa DeLong. (Fig. 5).

Head scarcely wider than pronotum, vertex angulate, one-half longer at middle than next eye, margin more acute at apex than next the eye. ♀ segment about twice the length of the penultimate, hind margin sinuate, notched at middle, lateral lobes slightly produced and rounded, black margin on median portion and a black line extending nearly half way to the base. ♂ valve large, broad, roundingly angulate, plates short, broad, narrowing to slightly produced rounded apices, numerous submarginal bristles, a light patch on disk and light border at apex. Dark gray, head, pronotum and scutellum yellowish white, closely inscribed or irrorate with fuscous; elytra milky white with

fuscous dots and pigment lines, with five more distinct spots on apical half of elytra; face dark with dense fuscous irrorations on a yellowish ground and four or five irregular frontal arcs. Length, ♀, 7 mm.; ♂ 6.5 mm.

Described from Tennessee, recorded for South Carolina, and specimens at hand from southern Ohio, Washington, D. C., Raleigh, N. C., South Carolina and Texas.

Phlepsius torridus Lathrop. (Fig. 6).

Head slightly wider than pronotum, vertex broadly angular, one-half longer at middle than next the eye, anterior edge bluntly angular. ♀ segment twice as long as preceding, median part slightly notched at middle, lateral angles obtuse. Golden brown, nearly uniform above, front dark with a few arcs, clypeus and loræ lighter, a light spot on the cheek just above the upper angle of the lora. Length, ♀, 6 mm.

Described from South Carolina. A specimen taken at Swannanoa, N. C., slightly larger agrees very perfectly with the type except that the ultimate ventral segment of the female is more depressed at the sides of the median lobe.

Phlepsius rileyi Baker. (Pl. XXVIII, Fig. 5).

Head scarcely wider than pronotum, vertex rather narrow, one-half longer on middle than against eye, distinctly angulate, bluntly angled with front, front in profile slightly concave near margin, below straight to clypeus. ♂ valve rather long, distinctly angulate behind, plates elongate, nearly twice length of valve, tips rather acute. Tawny, elytra irrorate with fuscous, vertex with two transverse bars; front brown, with indistinct whitish arcs and central line and spots near base. Length, 8 mm.

Texas.

Phlepsius brunneus DeLong. (Pl. XXVIII, Fig. 6).

Head scarcely wider than pronotum. Vertex flattened, distinctly but obtusely angled, half longer on middle than next the eye, margin acute at tip, rounding toward the eye. ♀ segment twice length of preceding, median part slightly produced, elevated, black margined, lateral lobes rounded. ♂ valve large, slightly longer than preceding segment, obtusely angled; plates broad at base, rather short, tips rounded. Brown with yellowish or whitish dots and irrorations. Front fuscous at base, brownish at tip, two dots below the margin, four or five irregular arcs. A large light spot on disc of the lora. Length, ♀, 7 to 7.5 mm.; ♂, 6 to 6.5 mm.

Tennessee (DeLong). East Sister Id., Lake Erie (H. O.).

Phlepsius texanus Baker. (Pl. XXIX, Fig. 1).

Head wider than pronotum; vertex short, obtusely angulate, slightly longer at middle than next the eye; front broad at base, tapering nearly uniformly to clypeus; pronotum more than twice as long as vertex, faintly concave behind; elytra broad, long, slightly flaring at tip. ♀ last ventral segment half longer than preceding; lateral angles slightly produced into short lobes, between which the border is nearly straight, margined with fuscous. ♂ valve short, obtusely angled; plates short, broad at base, tips broadly rounded. Dark gray, irrorate with fuscous; claval veins tipped with white; elytra clouded with fuscous patches, composed of fine lines and dots; legs banded with fuscous. Length, 6.5 mm to 7 mm.

Texas.

Phlepsius apertus VanDuzee. (Pl. XXIX, Fig. 2).

Head slightly wider than pronotum, vertex roundingly angulate, about one-third longer at middle than next eye, anterior edge bluntly angled. ♀ segment with a broad excavation, the middle third reaching to near base, lateral lobes quadrangular with the inner margin blackened. ♂ valve large, broad subangulate, plates broad at base, narrowing sharply to about the middle then extending as narrow bluntly tipped upturned processes exceeding the pygofer, much like *irroratus*. Dark gray, fuscous irrorations on whitish ground, an obscure whitish band crossing before the middle of the clavus and a whitish area at tip of clavus. Length, ♀, 6 mm.; ♂, 5 mm.

Northern U. S., extending from Maine to Rocky Mountains.

Phlepsius apertinus n. sp. (Pl. XXIX, Fig. 3).

Head slightly wider than pronotum, distinctly angulate, vertex about one-third longer at middle than next eye, acutely angled with front on apical third, one-half longer on middle than next the eye; front broad, sides parallel to antennæ, then narrowing sharply to clypeus; clypeus narrow, slightly wider at apex than at base, loræ broad, nearly reaching border of cheeks; pronotum strongly arched in front, shallowly concave behind; elytra slightly flaring. ♀ segment excavated on median third to base as in *apertus*, lateral lobes converging but not meeting at apex. ♂ valve much as in *apertus*, broad, obtusely angled behind; plates broad at base, narrowing to beyond the middle, terminating in blunt strap-like lobes; plates are longer and more nearly parallel than in *apertus*. Dark brown or blackish, vertex, pronotum and scutellum whitish with irrorations varying from dark fulvous to blackish; elytra with heavy dark fuscous or blackish pigment lines, leaving a distinct irregular light band before the middle of clavus, a few large whitish spaces on apical part of clavus and elytra, a series of dark, distinct blackish spots on the costa; front distinctly black at base, becoming lighter at clypeus with about four irregular broken

arcs; clypeus yellowish, a central dark line at apex; loræ irrorate with a lighter patch on outer border; legs annulate with fuscous. Length, ♀, 6.5 mm.; ♂, 6 mm.

This species is very much like *apertus* in the genitalia but the excavation on the female segment is wide at base and converging at tip and the male plates longer while the vertex is longer and more acute at tip and the narrow whitish band on the elytra presents a different picture.

Described from specimens collected at Corvallis, Oregon, by the junior author and Van Duzee and Thompson in California. Type and paratypes, in collections of the authors and Cal. Acad. Sci.

Phlepsius carolinus Lathrop. (Pl. XXII, Fig. 1).

Head wider than pronotum; vertex long, subangulate, one-third longer on middle than next eye, angulate with front; front in profile convex. ♀ segment twice as long as preceding, central area elevated and flat, laterally fluted, hind margin deeply sinuate on fluted portion. ♂ valve wide, short, rounding behind, plates narrowing uniformly to blunt tips, nearly three times as long as valve. Ashy gray, with slender irrorations and reticulations; vertex with dark spot near apex with slender light median line, expanding on tips, front brown with minute yellow dots, two light areas on each side of disc; no distinct arcs.

Specimens from South Carolina (Lathrop), Tennessee (DeLong).

Phlepsius particolor, Sanders & DeLong, (Pl. XXIX, Fig. 4).
Penna. Department of Ag., Vol. III, p. 15.

Head short, slightly produced; vertex one-half longer at middle than next to eye; margin bluntly angled at side, sharp at tip. Pronotum strongly arched, concave behind; elytra broad, tips flaring. ♀ segment produced, triangular, twice as long as preceding segment; apex with a broad incision narrowed at half its depth, and extending one-third its distance to base; margin and incision bordered with black. Vertex, pronotum and scutellum yellowish, slightly mottled with brown; elytra whitish, inscribed with dark brown; two white spots at tip of claval veins; costa with small irregular brown spots; face finely irrorate with brown. Length, ♀, 7 mm.

Kane, Pa.

Phlepsius fulvidorsum Fitch. (Pl. XXIX, Fig. 5).

Head scarcely wider than pronotum, vertex one-half longer at middle than next eye, angulate, margin acute at apex, more obtuse at eye. ♀ segment nearly twice as long as penultimate, posterior border slightly produced, raised on middle, lateral lobes prominent and depressed.

♂ valve rather large, obtusely triangular, plates broad at base, narrowing rather uniformly to acute, upturned apex. Vertex, pronotum and scutellum light fulvous, contrasting distinctly with the darker elytra. Elytra milky white with pigment lines and dots of fuscous and brown; face fuscous, minutely dotted with yellowish, frontal arcs distinct. Length, ♀, 6 mm.; ♂, 5.75 mm.

North-east U. S. west to Rocky Mountains, south to North Carolina. On grass in pine woods.

Phlepsius eburneolus n. sp. (Pl. XXIV, Fig. 3).

Similar to *fulvidorsum* but the ivory like anterior part of body contrasts still more sharply with the dark elytra and the female genital segment is quite different.

Head broader than pronotum, vertex obtusely angular, one-third longer at middle than next the eye, apex at center sharp-edged, ocelli close to eyes; front broad at base, tapering sharply to apex; clypeus narrow, nearly twice as long as wide, truncate at apex; loræ longer than broad, reaching nearly to margin of cheek; genæ slightly angled. Pronotum strongly curved in front, deeply sinuate behind; scutellum large; elytra densely marked with ramose lines. ♀ segment over twice as long as penultimate, narrowed and truncate behind, with a small central notch. ♂ valve triangular; plates elongate triangular, acute at tip. Vertex, pronotum and scutellum light ivory yellowish white with faint fulvous irrorations on the anterior margin of vertex, a faint broad fulvous stripe in the center of scutellum and the basal angles faintly fulvous. There are two blackish spots on the margin of scutellum each side and the elytral ramose lines are dark brown to fuscous, giving a chocolate tinge, although the interstices and cells are milky white. Fairly distinct spots of blackish occur on the elytra beyond the tip of clavus and along costal apical border and the legs are banded with blackish. Length, ♀, 5.25 mm.

Described from one specimen female, (type) in Osborn collection, labeled "Vinita, Ind. Ter. June 8, 1899" and collected by H. F. Wickham. A female (paratype) and ♂ (allotype) from Ashburn, Va., collected by L. A. Stearns. The first specimen has been in hand for many years and the description deferred in hopes that additional material and especially the male might be secured but this hope was not realized until the species was collected in Virginia by Mr. L. A. Stearns.

Phlepsius tullahomi DeLong. (Pl. XXIX, Fig. 6).

Head wider than pronotum, obtusely angulate; vertex one-fourth longer at middle than next the eye, somewhat depressed; margin acute at middle; front broad, narrowing nearly uniformly to clypeus; clypeus long, widening toward tip; loræ large, nearly reaching border of cheek; cheek margins rounded, gently sinuate. Pronotum about three times as long as vertex; hind border distinctly concave. ♀ segment one-half

longer than preceding, hind border sinuate at sides, with median produced tooth, notched at the middle. ♂ valve large, angled behind; plates broad at base, nearly triangular, tips acute. Length, ♀, 6 mm.; ♂, 5.25 mm.

Described from Tennessee, and specimens are in hand from Cantwell Cliff, Ohio, Aug. 4, 1921, (Osborn); Auburn, Alabama, May 23, 1922, "at light," (F. E. Guyton), and Pennsylvania, (De Long).

Phlepsius slossoni Ball. (Pl. XXII, Fig. 3).

Phlepsius franconianus Lathrop, Bull. 199, S. C. Ex. Sta., p. 93.

Head slightly wider than pronotum, broadly angular; vertex one-half longer on middle than next the eye. Anterior edge acute, sharpest at apex. Front slightly concave below apex of vertex. ♀ segment one-half longer than penultimate, posterior margin slightly produced and minutely notched on middle, shallowly sinuate laterally, lateral angles obtuse. Dark gray, a dull cloud on apex of vertex. Pronotum suffused with blackish on disc. Scutellum light. Elytra whitish with delicate dots and lines. Face white, minutely dotted with brown. Beneath whitish. Length, 6 mm.

Florida, South Carolina (F. H. L.), Southern Pines, N. C., (Manee).

Phlepsius fastuosus Ball. (Pl. XXX, Fig. 2).

Similar to *slossoni*, larger. Vertex short, obtusely angular; apex blunt, nearly twice longer at middle than next eye; disk flat; anterior margin thin, slightly foliaceous at apex. ♀ segment long, hind margin truncate, nearly two-thirds angularly produced, elevated, slightly notched at apex. Vertex brownish-gray, a cross on the apex; lateral margins and a few dots on the disk ivory white. Pronotum brownish-gray, irrorate with whitish; elytra milky white, with fine reticulations and small dots of brownish fuscous, mostly arranged in two bands, one rather narrow and definite across posterior third of clavus, the other broader, less distinct, occupying space behind clavus. Length, 7.5 mm.

New Mexico.

Phlepsius franconianus Ball.

Head wider than pronotum; vertex subangulate, margin thin, acute at tip, rounded near eye; front in profile concave above, convex below. ♂ valve triangular, two-thirds the length of the ultimate segment; plates long, triangular, their margins straight, apices acute, two and one-half times the length of the valve, slightly exceeded by the pygofers. Light gray; vertex and pronotum fawn color, elytra finely irrorate with brown lines and dots forming faint bands at middle of clavus at apex of clavus and before tip of elytra. Front minutely irrorate, a white mark at base, with faint indications of light arcs. Length, ♂, 5 mm.

New Hampshire.

Phlepsius lippulus Ball. (Pl. XXIX, Fig. 7).

Head wider than pronotum, vertex distinctly angulate, half to two-thirds longer on middle than against eye, flat, margin acute at tip, rounded near eye; front in profile, deeply concave above, convex below. ♀ segment long, about twice length of preceding, truncate, middle third produced into a feeble lobe. ♂ valve short; plates triangular, acute. Vertex, pronotum and scutellum gray, with whitish band back of middle of clavus, another at tip of clavus, forking midway and terminating on costa in two black spots; another band on apex blackish.

Florida, Mississippi, Texas.

Phlepsius fulviceps n. sp. (Pl. XXX, Fig. 1).

Similar to *strobi*, but with distinctly longer, angular vertex; the head fulvous; eyes red-brown; pronotum irrorate with fine yellowish dots; elytra milky white, with fulvous bands. Length, 5.25 mm.

Head scarcely wider than pronotum, distinctly angular; vertex twice as long at middle as next the eye; tip flattened; front concave below the tip, forming a flattened blunt margin; clypeus half longer than wide. Pronotum about two-thirds longer than vertex; hind border concave. ♀ segment about twice as long as preceding; hind border slightly sinuate, produced at middle into a broad obtuse tooth. Face, vertex, pronotum and scutellum pale fulvous; face with minute dots of yellowish; vertex with a faint trace of forked median line. Pronotum faintly irrorate with yellowish, transverse dots; scutellum with a yellow spot each side opposite the suture; elytra milky white with a fairly distinct fulvous band across at middle of clavus; another at tip of clavus dividing to form an arm to the costal dark spots; another near tip of apical areoles. There are numerous minute fuscous dots especially on the fulvous areas. Three dots on the costa and an apical spot at end of the apical band, fuscous. Beneath gray, minutely dotted with fuscous.

Described from one specimen, female, (type), collected at Leesville, La., April 28, 1905, by Wilmon Newell.

This species appears to be quite distinct, but has, until recently been supposed to belong to *lippulus*, Ball. It is, however, quite different from that species in the length of vertex and other characters, in some points being nearer to *strobi*, Fitch, from which it differs particularly in the length of vertex and the concave base of front.

Phlepsius uhleri Van Duzee.

Head wider than pronotum; vertex scarcely longer at middle than next the eye; front broad at base, narrowing with faint sinuation opposite eye; clypeus nearly twice as long as wide at base, widened to tip; cheeks broad, margins sinuate. ♂ valve short, obtusely angulate behind; plates triangular, outer margin slightly convex, tips acute,

scarcely acuminate, reaching tip of pygofer. Fulvous brown, minutely irrorate; elytra with indefinite lighter bands of whitish hyaline dots. 1st just back of scutellum, 2nd at tip of clavus, 3rd across base of apical areoles, middle one angled, reaching pretty closely to basal veins of anteapical areoles. Length, 4 mm.

"Odenton" Aug. 1, "Md." "Phlepsius uhleri V. Duz." Uhler's handwriting.

Phlepsius strobi Fitch. (Pl. XXX, Fig. 3).

Bythoscopus strobi Fitch, Fourth Report, N. Y. State Lab. N. H., p. 58, (1851). *Phlepsius strobi* Osborn, Ohio Jour. Sci., Vol. XXIII, p. 160, 1923, (not *P. strobi* Van Duzee).

"Resembling *Phlepsius uhleri* but with longer, angular edged vertex and with three whitish bands on elytra the anterior one extending from scutellum to half way point on clavus. Head wider than pronotum, vertex angular, one-half longer at middle than next the eye, margin angular; front longer than wide, clypeus with sides nearly parallel, apex truncate loræ nearly touching margin of cheek. Pronotum twice as long as vertex, hind border slightly emarginate. ♀ segment long with median third produced. ♂ valve short rounded behind, plates triangular, tips acute. Gray fulvus. Vertex fulvus mottled with whitish and with pronotum and scutellum brown, irrorate with gray or whitish, elytra with bands of white and brown, a white band across base from middle of scutellum to middle of clavus, another just beyond apex of clavus and the third just before the apex, inscribed with delicate brown lines." Length, ♀, 4.5–5 mm. ♂ 4.1 mm.

New York and Ohio.

Phlepsius punctiscriptus VanDuzee. (Pl. XXX, Fig. 4).

Head scarcely wider than pronotum, vertex half longer at middle than next the eye. Disc depressed. Anterior edge acute at tip, rounding near the eye. ♀ segment nearly twice the length of the preceding, slightly produced at middle, apex minutely notched, lateral angles scarcely produced. ♂ valve very small, plates narrowing sharply to about one-third from base then tapering to acute tips exceeding the pygofer. Light gray to whitish; vertex tinged with fuscous, with ivory white spots on the anterior border. Head, pronotum, scutellum and elytra with minute dots; face creamy white with minute brown dots leaving a fairly distinct median line on front and traces of obscure frontal arcs. Length, ♀ 7 mm., ♂ 5 mm.

Recorded from Florida, Tennessee, Kansas, Texas and Nebraska. Males referred to this species from Texas and Iowa.

Phlepsius planus Sanders & DeLong. (Pl. XXX, Fig. 5).

S. & DeL., Pr. Ent. Soc. Wash., Vol. XXIV, p. 98, 1922.

Related to *P. nebulosus* but with very short vertex. Markings of elytra in distinctly parallel lines. Head wider than pronotum, vertex

depressed short, scarcely longer on middle than next eye, anterior edge acute. Front scarcely concave below apex of vertex, broad, cheeks rounded, scarcely sinuated below eye. Pronotum short, anterior margin broadly curved; lateral carinæ distinct, long, about as long as short diameter of eye; posterior margin distinctly concave. Elytra long, claval veins straight and parallel, cross vein faint or wanting. ♀ segment about twice length of penultimate. Hind margin sinuated, incised on middle, lateral lobes rounded. ♂ valve short angulate behind; plates broad at base narrowing to middle, tapering to blunt upturned tips. Ash gray with brown or fuscous markings. Vertex whitish, minute brownish irrorations. Vertex with white spots on posterior edge behind ocelli. Face minutely irrorate with white dots, frontal arcs faintly indicated. Pronotum and scutellum irrorate with brownish and white. Elytra dull milky whitish, veins brown, mostly margined with pigment dots, lines of pigment dots in discal, apical, and anteapical cells. Beneath, gray. Length, ♀, 7 mm., ♂, 6 mm.

Redescribed from one female, four males, Gainesville, Fla., collected by C. J. Drake; one specimen Orlando, Fla., (G. F. Ainslie).

Phlepsius nebulosus VanDuzee. (Pl. XXIII, Fig. 4).

Head wider than pronotum, roundingly angular, vertex slightly depressed nearly twice as long at middle as next eye, anterior edge acute, front slightly concave at base; ♀ segment three times as long as penultimate, middle half nearly truncate, elevated, ridged laterally to form depressed lateral lobes which are rounded at angles; ♂ valve large broad angulate, plates long, strap-like, evenly tapering to divergent obtusely pointed tips, pygofer broad, exposed at sides of plates and much exceeded by the long plates. Gray brown, vertex and anterior border of pronotum dull yellowish with brownish irrorations, disk of pronotum darker with light irrorations scutellum yellowish sparsely irrorate with brownish; elytra whitish, subhyaline, with brownish pigment lines and dots, front fuscous with yellowish dots and about five fairly distinct arcs. Length, ♀ 8 mm., ♂ 8 mm.

Eastern U. S. to Colorado, also reported for Manitoba.

Phlepsius solidaginis Walk. (Pl. XXX, Fig. 7)

Head wider than pronotum, broadly angulate, vertex depressed margin acute, front scarcely concave below apex of vertex; ♀ segment twice as long as preceding, elevated and distinctly produced at middle with a small median notch, lateral lobes rounding; ♂ valve long, roundingly subangulate behind, plates long, tapering to acute tips. Light tawny with light irrorations, elytral rather densely reticulate with traces of transverse bands. Length, ♀ 7 mm., ♂ 6 mm.

Eastern U. S. and Canada west to Kansas and south to Tennessee.

Phlepsius josea Ball. (Pl. XXX, Fig. 6).

Similar to *humidus*, much smaller. Vertex flat, slightly depressed posteriorly; twice as long at middle as next the eye; front margin thick but foliaceous. ♀ segment one-half longer than preceding; hind margin roundingly truncate; lateral angles rounded; ♂ valve very small, rounding, almost concealed; plates broad at base, semi-circularly rounding; thin, produced into long style-like attingent points. Pale yellowish-olive, flecked with irregular spots and blotches of blood red, giving a red appearance to the whole insect above and below. Length, 5.25 mm.

Colorado.

Phlepsius occidentalis Baker. (Pl. XXXI, Fig. 2).

Head scarcely wider than pronotum. Vertex roundingly angulate, one-half longer on middle than against the eye, depressed, margin acute. Front feebly concave below apex of vertex. ♀ segment more than twice as long as preceding, slightly produced and minutely notched at middle, lateral angles obtuse, margin blackish on each side of central notch. ♂ valve rather large, subangulate; plates short, broadly triangular, together nearly equilaterally triangular. Tips acutely converging, slightly upturned. Dark gray. Vertex and pronotum fuscous with whitish dots or irrorations. Vertex and scutellum lighter than pronotum. Elytra milky white with dense fuscous dots and pigment lines. Front fuscous with minute light dots, irregular arcs, a broad light spot on loræ, and whitish band across middle of clypeus. Male hitherto undescribed differs from female in having vertex slightly longer on middle, margin between vertex and front distinctly marked with ivory white.

Described from State of Washington. Specimens in hand from Pullman, Wash.; Corvallis, Ore.; and reported for San Diego, Cal.

Phlepsius nudus Ball. (Pl. XXXI, Fig. 1).

Similar to *ramosus* but not slender; vertex roundingly angled; disk flattened anteriorly; margin thin, produced. Pronotum short, scarcely longer than vertex; elytra broad, short. ♀ segment of female truncate behind, surface strongly convex with a sharp median carina and traces of two lateral ones. ♂ valve equilaterally triangular; apex rounded; plates narrow, long, spoon-shaped, three times the length of the valve, narrowly rounded at apex. Dull straw, slightly tawny on vertex; disk of pronotum and angles of scutellum washed with brown; disk of scutellum pale with a pair of brown points. Elytra sub-hyaline, somewhat milky; veins and ramose lines tawny-brown. Length, ♀ 6 mm.; ♂ 5 mm.

Florida.

Sub genus PARAPHLEPSIUS Baker.

Phlepsius bifidus Sanders & DeLong. (Pl. XXXI, Fig. 3).

Ann. Ent. Soc. Am., Vol. X, pp. 89, 1917.

Head slightly wider than pronotum, roundingly angular. Vertex one-third longer on middle than next eye, flattened, slightly depressed behind the margin; margin acute, sharpest at middle. Front flattened, barely concave below apex of vertex. ♀ segment long, deeply notched on middle, lateral lobes angularly rounded, blackish on apical half. ♂ valve broad, distinctly angular; plates broad at base, narrowing abruptly to rounded tip, together about equilaterally triangular. Dark gray, vertex yellowish with rather sparse irrorations, pronotum yellowish on anterior border, darker on disc, with light irrorations. Scutellum ivory whitish, with a few irrorations. Elytra milky white, with dark fuscous pigment lines, denser behind middle, leaving a suggestion of a lighter band before the middle. Face dark, base of front blackish, apical portion lighter, traces of two or three faint light arcs. Length, 7 mm.

Described from Wisconsin. Specimens in hand, collected at Cranberry Lake, by C. J. Drake and H. Osborn; Elka Park, Greene Co., N. Y. (Drake).

Phlepsius ramosus Baker. (Pl. XXXI, Fig. 4).

Head distinctly wider than pronotum, roundingly angulate, vertex distinctly depressed, margin acute, almost foliaceous, front concave below apex of vertex; pronotum distinctly carinate laterally. ♀ segment nearly three times as long as penultimate, somewhat produced and carinate on middle, lateral angles obtuse. ♂ valve broad, short, roundingly subangulate, plates broad at base, narrowed abruptly to about middle then tapering to blunt points which extend beyond pygofer. Dark brown or fuscous, vertex, pronotum and scutellum fuscous with numerous dots and irrorations; elytra milky whitish with dark fuscous lines and dots more dense behind the middle, leaving a fairly distinct band from base to middle of elytra; front fuscous with minute yellowish dots and traces of arcs. Length, ♀, 7 mm.; ♂, 7 mm.

North-east U. S. west to Ohio.

Phlepsius tenuifrons Sanders & DeLong.

Ann. Ent. Soc. Am., Vol. XII, p. 235, 1919.

Head broader than pronotum; vertex produced, upturned, nearly twice as long at middle as next the eye. Pronotum short, scarcely twice as long as vertex; elytra short, broad, flaring. ♀ segment long, three and one-half times preceding segment; lateral angles rounded; hind border sinuate, a shallow notch separating two small lobes at middle. ♂ valve long, roundingly angled behind; plates broad at base, narrowed abruptly before middle; tips long, blunt, passing the pygofer. Pale, with numerous brown irrorations; a brown line on vertex; face

uniformly irrorate, pale spot at upper end of loræ; elytra milky white, heavily marked with ramose lines; an indistinct saddle across middle, veins brown; beneath uniformly brown. Length, 7 mm.

Greensburg, Pa.

Sub genus ZIONINUS Ball.

Phlepsius extremus Ball. (Pl. XXXI, Fig. 5).

Vertex flattened; head scarcely as wide as pronotum; vertex broad, nearly twice as wide as long at middle, nearly twice as long on middle as next eye; head sub-angulate; front broad at base, narrowing uniformly to clypeus; clypeus long, broad at base; pronotum half longer than vertex; scarcely concave behind; elytra slightly longer than abdomen. ♀ last ventral segment twice as long as preceding, bisinuate on hind margin, faintly sinuate at middle. Light gray, marked with fuscous or black. Vertex mottled with blackish; front rather delicately inscribed with fine brown lines, clypeus and loræ with fine dots. Pronotum, scutellum, elytra whitish marked with black dots or lines. The ramose lines of elytra sparse. Length, ♀, 5 mm.

Described from Colorado, and recorded from California.

Specimen at hand collected by E. P. Van Duzee, Ashland, Oregon, Aug. 2, 1919. The species is characterized by the distinctly flattened vertex.

Sub genus TEXANANUS Ball.

Phlepsius eugeneus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 384, (1918).

"Nearly of the form of *excultus*, but larger, paler, and lacking the definite markings of that species. Pale grayish or slightly fulvous brown. Length 7 mm., width 3 mm. Vertex convex, one-fourth longer on middle than against eye, twice wider than long. Anterior margin bluntly rounding except at apex, front broader than in *hebraeus*, almost parallel margined until just before the apex. Pronotum but little wider than across eyes. Elytra longer than in *excultus*, flaring behind, the inner anteapical cell very long, the outer one broadest in front. ♀ segment long, angularly narrowing posteriorly, middle half roundingly emarginate clear to the base, where there is a slight median tooth. Male valve very short and obtuse; plates large, triangular, with nearly straight margins, white with black spots at the base of the short marginal hairs; the stout spines of the pygofers exceeding those of the plates. Pale yellow, two pairs of approximate dots on suture between vertex and pronotum, as in *excultus*, two indistinct brown spots at apex of vertex, and front brown with pale dots. Elytra milky, inscribed with brown, faintly washed with rufous in most specimens, the tips of the claval nervures fuscous."

Described from various points in Guerrero, also Cuernavaca, and Iguala, Mexico.

Phlepsius superbus Van D. (Fig. 7).

Head narrower than pronotum; vertex roundingly angulate, about one-third longer on middle than at eyes, rounding to front; front profile scarcely convex. ♀ segment broadly roundingly emarginate, about as long at middle as preceding segment. ♂ valve narrow, rather long, slightly angulate behind; plates short, broad, borders rounded, together semicircular. Brown with irrorations and reticulations dark fuscous or blackish; front blackish at base with brownish arcs and light mottlings. Length, 6 mm.

South Carolina, Southern Florida to California, south to Central Mexico.

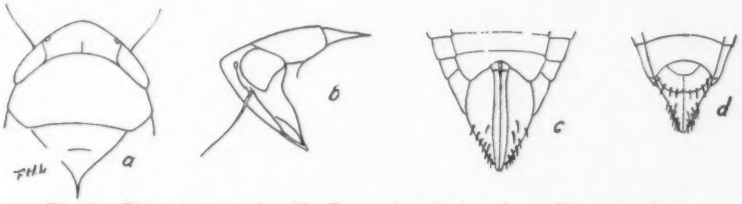


Fig. 7. Phlepsius superbus VanD. *a*, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius excultus Uhler. (Fig. 8 and Pl. XXIII, Fig. 2).

Head almost as wide as pronotum; vertex short, roundingly subangulate, about one-fourth longer on middle than next to eye, rounded to front, profile of front slightly convex. ♀ segment roundingly excavated to near the base, on median half, exposing lobes of pygofer and base of ovipositor. ♂ valve short, rounded behind, plates triangular, outer border slightly convex, tips acute. Head, scutellum and pronotum tawny, with scattered, fuscous lines strongly contrasting with elytra; elytra ivory white, densely covered with blackish or fuscous reticulations, with lobate white spots, nerves blackish. Front mottled with light dots, not arranged in arcs. Length, ♂, 6 mm.; ♀, 6.5 mm.

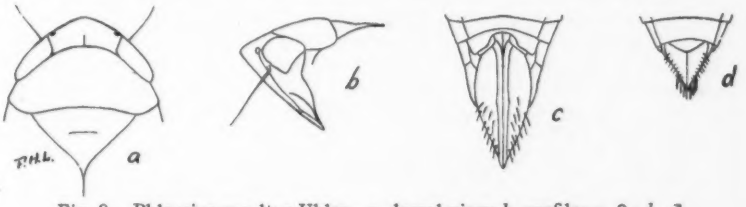


Fig. 8. Phlepsius excultus Uhler. *a*, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Southern U. S., North Carolina, Florida, to Texas. Also "Mex." Ball. Van Duzee also notes Massachusetts, New York, New Jersey, Pennsylvania, Tennessee, Illinois, Kansas, Minnesota and Colorado.

Phlepsius rufusculus n. sp. (Pl. XXXI, Fig. 6).

Head slightly narrower than pronotum; vertex faintly subangular, about one-fourth longer on middle than next eyes, obtusely rounded to front, profile of front scarcely convex. ♀ last ventral segment nearly twice as long as preceding, faintly produced at middle with very shallow, median notch. ♂ valve narrow, subtriangular, roundingly angular behind, plates short subtriangular, finely ciliate, reaching tip of pygofers. Yellowish with reddish brown irrorations, vertex mottled with yellow and brown, anterior border ivory yellow; front with distinct brown arcs separated by median brown area, including minute yellow dots. Length, ♂, 7 mm.; ♀, 7.25 mm.

One female (type) from West St. Louis, Mo.; W. V. Warner, collector. Male (allotype), Portsmouth, Ohio, C. J. Drake, collector.

Somewhat resembles *superbus*, but differs in distribution of mottlings in front and especially in form of genitalia of both sexes. Agreement of structural and color characters makes the associations of sexes here indicated practically certain.

Phlepsius umbrosus Sanders & DeLong. (Pl. XXXII, Fig. 2).
Ann. Ent. Soc. Am., Vol. X, p. 88, 1917.

Head scarcely narrower than pronotum; vertex obtusely angled, nearly twice as long at middle as next the eye. Pronotum strongly convex, twice as long as vertex; elytra broad, broadly rounded at tips. ♀, last ventral segment twice as long as preceding; lateral angles produced, sharply rounded; hind margin convex, notched at middle, forming two produced rounded lobes, margined by a broad semi-circular brown spot extending one-half way to base. ♂ valve nearly as long as last ventral segment, slightly concave; apex obtuse; plates long, evenly narrowed to small blunt points. Dark brown; vertex evenly irrorate, a pale spot each side next to eye. Pronotum irrorate and punctulate; elytra milky white, closely and evenly inscribed with dark brown; face dark brown, evenly irrorate with testaceous. Length, ♀, 6 to 6.5 mm.

Described from Grand Rapids, Wis.

Phlepsius cumulatus Ball. (Pl. XXXII, Fig. 1).

Broadly oval, head narrower than pronotum, vertex short, scarcely longer on middle than next eyes, faintly angulate, bluntly rounded to front; front in profile scarcely convex. ♀ ventral segment longer than preceding, nearly truncate, rather broadly notched at the middle, with a shallower notch each side. ♂ valve triangular, plates twice length of valve, sides roundingly angulate, tips slightly angularly divergent. Grayish tinged with reddish, reticulations faint; vertex with faint fuscous dots forming a transverse line in front of which is

a series of faint dots; front black on base with yellow dots, arcs distinct, blending with maculations on middle. Length, 6–6.5 mm.

On plains grasses, Western plains, Kansas, Nebraska, South Dakota.

Phlepsius ovatus Van D. (Pl. XXXII, Fig. 6).

Ovate, less robust than *decorus*, head narrower than pronotum, vertex about one-third longer on middle than against eyes, rounding to front; front scarcely convex. ♀ segment slightly emarginate, notched at center. ♂ valve long, triangular, plates short, outer margin curved, together nearly semicircular. Whitish with heavy black or fuscous reticulations on elytra. Vertex with transverse white band interrupted by longitudinal median stripe. Front with irregular arcs at sides, breaking into irrorations on disc. Length, ♂ 4.75 mm.; ♀, 5 mm.

Western Tennessee, Kansas, Colorado, Texas, Oregon; "South to southern Mexico." Ball.

Phlepsius mexicanus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 385, (1918).

"Closely resembling *P. areolatus*, but quite distinct in shape of vertex and genitalia. A stout species with the brownish fuscous irrorations irregularly distributed, leaving patches of milk white. Length 6.75 mm.; width 3 mm.

Vertex convex, with the front almost conical, nearly half longer on middle than against eye, almost three times wider than long, front broad wedge-shaped, but little longer than its basal width. Elytra broad and short, the apices appressed; apical cells short. ♀ segment reduced, less than two-thirds as wide as the penultimate, consisting of an obtusely triangular plate with the apex produced into a strap-like tooth as long as the segment. A pair of broad plates arising under this segment cover the base of the pygofers and a pair of heavy folds occupy the corners. ♂ valve rounding, plates narrow, scarcely as wide as the valve, concavely narrowing to the blunt points, two and one-half times as long as the valve, not quite as long as the compressed pygofers. Vertex testaceous brown, three irregular blotches on the anterior margin and numerous dots on the disc pale; pronotum testaceous brown, with irregular hieroglyphic light markings on anterior half and light pustulate spots on the remainder. Scutellum with the apex and two marginal spots light. Elytra milky white, the nervures fuscous brown, the vermiculation mostly coalesced into fuscous dots which are larger toward the margins."

Described from Orizaba and Chilpancingo Mexico.

Phlepsius distinctus Lathrop (Pl. XXII, Fig. 2).

Head narrower than pronotum, vertex narrow, subangulate, about one-third longer on middle than next eye, rounding to front. ♀ segment slightly longer than preceding, shallowly emarginate. Ivory white with heavy blackish maculations and blackish irrorations, three con-

spicuous lobate commisural spots white, containing minute black spots in the margin, corium with numerous white areas, front irrorations blending irregularly with arcs scarcely indicated. Length, 5 mm.

South Carolina (Lathrop), North Carolina, Florida, Mississippi (H. O.).

Phlepsius graphicus Ball. (Pl. XXXII, Fig. 5).

Somewhat similar to *decorus*, but paler and with the commissural lobes less pronounced. Head short; vertex one-fourth longer at middle than next the eye; front broad, sinuate, roundingly narrowed from antennal pits; clypeus twice as long as wide; loræ large, almost reaching margin of cheek. Pronotum twice as long as vertex; elytra broad, tapering, slightly flaring. ♀, last ventral segment twice as long as preceding; hind border sinuate and deeply notched at the middle, with a prominent tooth each side the median notch formed by a distinct incision; lateral angles sloping, rounded. ♂ valve short, obtusely angular behind; plates short; outer margins convex; tips blunt, a little more than half as long as pygofer. Yellowish-gray, with vertex, pronotum and scutellum faintly irrorate with pale fuscous or brownish; elytra with rather dense ramose lines and dots; veins fuscous. Beneath pale yellowish; legs spotted. Length, ♀, 6 mm.; ♂, 5.5 mm.

Ft. Collins, Colo.; Kimball, Neb.

Phlepsius annulatus n. sp. (Pl. XXXII, Fig. 3).

Somewhat similar to *decorus*, smaller, tinged with rosaceous, female segment with a square excavation on the posterior third. Head narrower than pronotum, vertex narrow, convex, sloping anteriorly, one-third longer on middle than next the eye, margin obtuse, almost rounded. Ocelli close to the eye. Front scarcely convex, narrowing gradually to the clypeus, cheeks scarcely sinuate beneath the eye. Pronotum strongly arched in front, lateral carina equalling short diameter of eye. Claval veins approaching each other with a cross vein in middle. ♀ segment short, a deep quadrangular excavation on the middle, lateral lobes sinuous and lateral angles rounded. ♂ valve small, angled; plates convex, nearly semicircular, nearly reaching tip of pygofer. Vertex, pronotum and scutellum and inner border of clavus yellowish, more or less irrorate with fuscous. Elytra milky white or hyaline, marked with dark brown and fuscous, female with conspicuous spots at ends of claval nervures. In the male these are less conspicuous, but the pigment lines in the elytral cells appear more numerous. A number of distinct dark patches appear in the costal cells. A rosaceous tinge on elytra of female. Face dark fuscous with yellowish dots, about four oblique arcs on the front. Two distinct fuscous spots on base of clypeus. Legs yellowish, conspicuously annulated with black. Length, ♀ 5.5, ♂ 5 mm.

Described from one female from the base of Mt. Hood, and one male from Alsea Mt., Oregon. (Lathrop). On undergrowth at edge of fir forest.

Phlepsius notatipes n. sp. (Pl. XXXII, Fig. 4).

Similar to *decorus* in size and pattern, but paler and with the legs marked with numerous black dots, those of the femora in longitudinal series. Head narrower than pronotum, short, faintly angulate; vertex slightly longer at middle than next the eye; front broad at base; lateral margin somewhat convex; clypeus widened at tip; loræ large, nearly touching margin of cheek; cheeks broad, distinctly sinuate. Pronotum twice as long as vertex, broadly rounded before, faintly concave behind; elytra short, broad, rounded at tip, slightly longer than abdomen. ♀ last ventral segment short, scarcely longer than preceding; hind border sinuate, slightly produced toward the center, a deep median notch, outside of which is a shallow notch just inside the produced part. ♂ valve small, obtusely angulate behind; plates short, sub-triangular; outer border slightly convex; tips bluntly angular, reaching about two-thirds of the way to the tip of the densely setose pygofer. Light gray; vertex with a faint fuscous pattern of minute irrorations; front dark fuscous with numerous dots and irregular arcs; a few dots on loræ and cheeks. Pronotum, scutellum and elytra with minute fuscous or blackish irrorations and lines; the claval border with three faint ivory white lobes, including minute black lines; the tips of claval veins black. Beneath gray; legs minutely dotted with fuscous and black; the female segment margined with light fuscous; pygofer dotted with light. Length, ♀, 5.75 mm.; ♂, 5.5 mm.

Described from three females, (type and paratypes), and one male, (allotype), collected by F. H. Lathrop at Pullman, Washington, August 11, 1919. On dry hillside, from grass.

Phlepsius hosanus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 386, (1918).

"Form and general appearance of *decorus* O. & B., slightly smaller and with a definite concave light line between the ocelli. Length 6 mm., width 2.5 mm.

"Vertex transversely convex, slightly sloping to the narrow margin, one-fifth longer on middle than against eye, twice wider than long. Front moderately broad above, wedge-shaped, distinctly longer than wide. Pronotum but little wider than across the eyes. Elytra longer and more flaring than in *decorus*. ♀ segment short, posterior margin nearly truncate with four triangular teeth on the middle third, the outer pair the larger. Vertex brownish fuscous; a spot at apex, the line between ocelli and the base ivory white. Pronotum with tawny markings on the anterior third. Scutellum tawny with light and black spots. Elytra ivory white, with fuscous irrorations coalescing into irregular spots, omitting the inner margin back to apex of clavus. This ivory margin is narrow next the scutellum and is crossed by the inner claval nervure. It widens out on middle of clavus and again before apex and usually bears one or more black spots in each expansion."

Described from Orizaba, V. C. and Tepetlapa Guerrero, Mexico.

Phlepsius decorus O. & B. (Fig. 9).

Robust, elytra flaring, head narrower than pronotum; vertex broadly, roundingly angulate, about one-third longer on middle than against eyes, anterior margin bluntly angulate. Front in profile scarcely convex. ♀ segment slightly longer than preceding, hind border truncate with a deep circular notch bordered with brown. ♂ valve small, rounding behind, plates short, triangular, acute at apex. Dull ivory white, tinged with tawny on head, pronotum and scutellum; vertex irrorate with fuscous, with transverse whitish band extended forward to apex at middle, inner margin of elytra ivory white, broadening into lobes on the sutural margin. Front with short fuscous arcs merging into confused irrorations on central portion.

Iowa, Illinois, Ohio, New York, Maine, North Carolina, Tennessee, Florida.

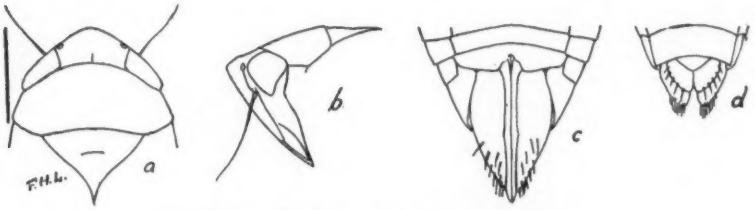


Fig. 9. Phlepsius decorus Osb. and Ball.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius areolatus Baker. (Pl. XXIV, Fig. 2).

Head narrower than pronotum; vertex subangulate, one-third longer on middle than against the eyes, anterior edge sharp, front straight in profile. ♀ segment twice as long as preceding, hind border nearly truncate, slight notch on middle. Ivory white, distinctly tessellate with brown, fuscous and black irrorations or maculations; anterior border of vertex with alternating ivory and black spots, frontal arcs slender, irregular, merging on middle. Length, 6 mm.

Kansas.

Sub genus IOWANUS Ball.

Phlepsius spatulatus VanD. (Pl. XXXIII, Fig. 1).

Head narrower than prothorax; body long, slender, vertex one-half longer on middle than next eye, rounding to front, front slightly convex in profile; elytral reticulation rather coarse, less distinct than in *majestus;* elytra long, narrow. ♀ segment longer than penultimate, slightly produced on middle, with slight median notch. ♂ valve short, roundingly angular behind; plates narrow, tapering nearly uniformly to acute tips. Ashy brown; vertex with mottled transverse band between eyes, in front of which are two triangular mottled spots.

Frontal arcs irregular, meeting on middle. Length, ♂, 6.5–7 mm.; ♀, 7 mm.

Colorado, California, Kansas, Texas, Mexico, along the border, to Central Mexico. Two specimens (Osborn collection) from the Canal Zone.

Phlepsius spatulatus, var. **personatus** Baker.

This form differs from the typical *spatulatus* in being light colored, pale gray or whitish, with faint dots and irrorations with a fairly distinct fuscous band between the eyes and a distinct black dot on the base of the last ventral segment of the female. The genitalia seem to agree entirely with *spatulatus* and the color differences too variable to warrant the separation as a distinct species.

Phlepsius sabinus, Sanders & DeLong.
Penna. Dept. Ag., Vol. III, p. 15, 1920.

Similar to *spatulatus*, but darker; head narrower than pronotum, distinctly produced, bluntly angled; vertex one-half longer at middle than next the eye. Pronotum strongly arched; elytra long, narrow. ♀ last ventral segment two and one-half times length of preceding, margin truncate with median broad bifid tooth, nearly one-third length of segment. Vertex white toward apex, with broad, irregular black band between eyes, brown posteriorly, and two black triangular spots toward apex. Pronotum pale, variously mottled and splashed with brown, numerous tiny punctures most abundant posteriorly. Lateral margins bordered with white. Scutellum brown mottled anteriorly and pale posteriorly. Elytra milky white, irregularly inscribed and mottled with dark brown pigment. Face pale buff, with nine or ten pairs of irregular brownish arcs, a broad median pale line and with black band at base of clypeus. Margin of frons near antennæ, irregular spot and broad line below eyes extending across pronotum below margin black. Venter pale beneath, except first abdominal segment and sometimes a broad median band, black.

Arizona.

Phlepsius denticulus n. sp. (Pl. XXIV, Fig. 4).

Similar to *ovatus*, but smaller; head more distinctly angulate and genitalia different.

Head narrower than pronotum; vertex distinctly angulate, nearly twice as long at middle as next the eye, rounded to front; front broad at base, narrowing nearly uniformly to clypeus; clypeus about twice as long as broad, expanded at tip; loræ large; cheeks expanded at sides, margins distinctly sinuate. Pronotum about half longer than vertex; lateral carina about one-half the length of the eye, hind border slightly concave; elytra broad, slightly flaring at tip. ♀ last ventral segment with a pair of rather strong teeth divided by a median notch, lateral angles produced into blunt teeth. ♂ similar to superbus; valve small,

angled behind; plates short, broad, bluntly rounded behind, about one-half as long as pygofer, not as nearly semicircular as in superbus. Dull gray, tinged with brown; vertex and pronotum faintly irrorate with fuscous; scutellum with a central dark line; elytra gray, subhyaline, with fuscous ramose lines more or less distinct; costal border with a series of dark spots more pronounced at tip; front brownish or light fuscous, with pale arcs and dots; clypeus pale, with a median darker stripe; loræ with dark spots on the disk; abdomen above blackish, below dark gray; legs light brownish with fuscous annulations and dots. Length, ♀, 4.25–4.75 mm.; ♂, 4–4.5 mm.

Described from a series of eleven specimens, four females and seven males, Los Banos, California, May 23, 1918, collected by E. P. Van Duzee.

This species has considerable appearance of a minute and light colored *superbus*, but has a longer vertex and the female segment is decidedly different, while the male plates are similar to that species.

Phlepsius neomexicanus Baker. (Pl. XXXIII, Fig. 2).

Head distinctly narrower than pronotum; vertex about one-third longer on middle than at eye; edge subacute, front slightly convex in profile, front broader than in spatulatus; elytral reticulations coarse. ♂ valve narrow, short, distinctly obtusely angulate; plates broad at base, narrowing behind center, extending into acute tips reaching half way to extremity of large, remarkably elongated, pygofers. Ash gray, fuscous irrorations, vertex light gray with faint, central, broken line, anterior margin with faint irregular brownish marks and circular dots, fairly dark cresentic spots on anterior border of pronotum, frontal arcs indicated by light maculations on brownish base. Length, 6 mm.

New Mexico.

Phlepsius incurvatus n. sp. (Pl. XXXIII, Fig. 3).

Head narrower than pronotum, distinctly angulate, subconic; vertex a little wider than length at middle, nearly twice as long at middle as next the eye, rounded to front, more acute at apex; front rather narrow, tapering to clypeus; clypeus scarcely widening toward tip; loræ large, elongate, nearly reaching tip of clypeus; cheeks narrow, distinctly narrowed below. Pronotum strongly arched in front, two-thirds longer than vertex, hind border concave. ♀ segment deeply incurved at middle, only about half as long as preceding segment. ♂ valve small, triangular; plates broad at base, sinuate; tips narrow, acute, reaching two-thirds length of the pygofer; pygofer large, not as long as in *neomexicanus*. Light gray, more or less irrorate with fuscous; vertex, pronotum and scutellum pale; front dusky, mottled; clypeus mottled with pale fuscous; elytra whitish, sub-hyaline, distinctly inscribed with fuscous and black lines; the claval veins at tips, and costal cross-veins conspicuous. Length, ♀, 5.75 mm.; ♂, 5.5 mm.

Two specimens, male and female, Sabino Canyon, Catalina Mountains, Arizona, 518, E. P. Van Duzee collection; one specimen, female, Imperial County, California, R. Hopping, Collector, E. P. Van Duzee collection.

Phlepsius cinerosus n. sp. (Pl. XXXIII, Fig. 4).

This species is apparently most closely related to *spatulatus* and *neomexicanus*, but may be distinguished by its smaller size, its pale color, absence of color markings and different genitalia. Vertex narrower than in spatulatus; angulate, half longer at middle than next the eye, genæ distinctly sinuate below the eyes. ♂ valve obtusely triangular; plates long, broadest on the base, narrowing on the basal region, tips together broadly rounded. Pygofers somewhat exceeding the plates laterally. ♀ segment nearly three times the length of the preceding; moderately narrowed posteriorly, the posterior margin almost truncate with a triangular notch in the middle. Faded yellowish, approaching *cinereus*. Vertex with a few, rather obsolete deep yellow markings. Eyes fuscous. A number of arcs on the front, the genæ below the eyes, and spot on the lora and clypeus, fuscous. Pronotum and scutellum practically without markings, and the reticulations of the elytra all but obsolete. Length, 6 mm.

Described from one female (type) and one male (allotype) from Springer, N. M., collected by C. N. Ainslie. Types in National Museum.

Phlepsius delicatus n. sp. (Pl. XXXIII, Fig. 5).

Very light gray, faintly marked with delicate ramose veins. Head a little narrower than pronotum; vertex broad, about one-third longer at middle than next the eye, obtusely angulate, rounded to front; front broad, roundingly narrowed to clypeus; clypeus twice as long as width at base, distinctly widened toward the tip; loræ large, almost touching margin of cheek; cheek margin distinctly sinuate. Pronotum twice as long as vertex, lateral margin one-half as long as eye, distinctly carinate; hind border slightly concave; elytra moderately broad, slightly flaring toward the tip. ♀ segment short, concave; lateral angles prominent similar in form to superbus. Light gray or whitish; vertex and pronotum faintly irrorate with darker gray; elytra milky white, delicately inscribed with ramose lines, a larger dark dot at ends of claval veins, and a series of dots on costal border. Beneath and legs pale gray or whitish, the fore femora and all tibiæ externally dotted with black. Length, 5 mm.

Described from one specimen, female, (type), collected by E. P. Van Duzee at Palm Springs, California, May 21, 1917.

Phlepsius elongatus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 382, (1918).

"Resembling *majestus*, but narrower with a longer, flatter vertex and a long acuminate female segment. Vertex transversely depressed, nearly flat on anterior half, acutely angled with the long narrow front, one-third longer on middle than against eye, half wider than long. Pronotum much wider than vertex, the outer angles prominent. Elytra very long and narrow. ♀ segment continuing full width as long as the penultimate, then tapering into a long, slender point extending almost to apex of pygofers. Vertex pale testaceous; the anterior third black except for a narrow light margin and a median line; a spot against either eye near the base and an irregular band on middle brownish or fuscous. Front pale, with fuscous arcs, the upper pair very distinct and margining the vertex, below they coalesce into an irregular spot on the disc. Pronotum pale, irregularly mottled with brown, three fairly definite fuscous spots on the anterior sub-margin behind each eye. Scutellum fulvous, with six light points. Elytra pale, fulvous, uniformly inscribed with testaceous. Length, ♀, 10 mm."

Described from a single female from Mexico.

Phlepsius handlirschi Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 383, (1918). Fig. 3b, c and d.

Form and general appearance of *majestus* Osborn and Ball. Slightly smaller and with a narrower vertex. General color, fulvous brown. Vertex pale yellow with a broad band and two sub-apical spots black. Vertex and face as in *hebraeus*. Elytra slightly broader and less flaring, second and third apical cells long and curved. ♀ segment short, transverse; posterior margin nearly straight, the median third produced on each side of a narrow median notch extending over half way to the base; angles next this notch acute. ♂ valve semicircular, plates long, acutely triangular, the extreme tips rounding, three times as long as the valve. Vertex pale yellow, a transverse band behind the ocelli widening on the disc and interrupted in the middle, and a pair of spots in front of this, black; this band incloses a yellow dot against each eye. Face pale sordid yellow. Short brown arcs on front and a dark ocellate spot on clypeus. Pronotum pale, coarsely irrorate with fulvous brown, the anterior sub-margin with coarse ocellate dark spots. Elytra pale, rather sparsely inscribed with fulvous; three dark spots along the suture. Length, 9–10 mm. (Adapted from Ball.)

Described from Mexico.

Phlepsius hebraeus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 383, (1918).

Resembling *handlirschi* in general form and appearance, slightly smaller; color and marking similar but slightly paler. Vertex transversely convex, one-fourth longer on middle than against eye, twice

wider than long, the anterior margin bluntly rounding to front; front long and narrow, the margin straight to just before the apex. Pronotum broad, the outer angle sharp. Elytra long and narrow; the anteapical cells parallel margined, a number of extra cells on the costa opposite the anteapicals. ♀ segment moderately long, posterior margin slightly concave with a small semi-circular median notch. Vertex and face marked as in *handlirschi* and *majestus*. Pronotum pale, irrorate with brown and with a few black spots along the anterior sub-margin. Elytra as in *handlirschi*, but lacking the rufous cast and usually with a few definite light spots in the apical cells. Length, 8.5–9 mm. (Ball.)

Described from Mexico.

Phlepsius majestus O. & B. (Pl. XXII, Fig. 4).

This is the largest species of the genus, and may be easily distinguished from the other forms by its size and rich tawny color. Vertex twice as long, scarcely impressed on the disc; front long and narrow, apical suture obsolete. Elytra long and narrow. ♀, ultimate ventral segment scarcely twice the length of the penultimate; the posterior margin shallowly sinuate on each side of a median cleft; the lateral angles prominent, broadly rounding. ♂, valve narrower than the ultimate segment, the apex truncate; plates rather long, triangular, the tips together, broadly rounding; the lateral margins thickly set with thin spines; pygofers exceeding the plates laterally, clothed with spines. Vertex pale with a conspicuous irregular, transverse fuscous band on the middle. Face pale, with the sutures and a number of arcs on the front fuscous; genæ with obscure fulvous blotches. The fulvous markings on the pronotum and scutellum and the prominent fulvous reticulations on the elytra, give the insect a rich fulvous or tawny color. Length, ♀, 9.5–10 mm.; ♂, 9–9.5 mm.

Iowa, Ohio, New Jersey, North Carolina, Texas. On grass in open woods.

EXPLANATION OF PLATES.

PLATE XXII.

Fig. 1. Phlepsius carolinus. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron.
Fig. 2. Phlepsius distinctus. *a*, dorsal view; *b*, profile; *c*, face; d, ♀; *e*, elytron.
Fig. 3. Phlepsius slossoni. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron.
Fig. 4. Phlepsius majestus. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron; *f*, ♂.

PLATE XXIII.

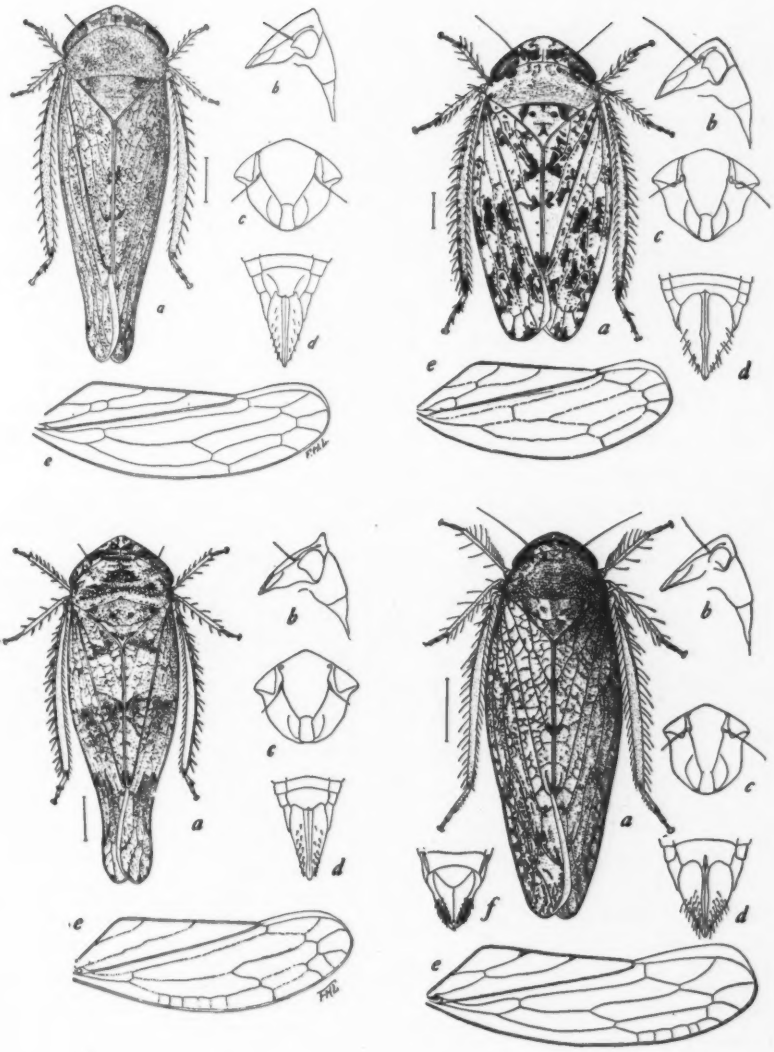
Fig. 1. Phlepsius maculosus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.
Fig. 2. Phlepsius excultus. *a*, face; *b*, ♀; *c*, elytron.
Fig. 3. Phlepsius micronotatus. *a*, profile; *b*, face; *c*, ♀; *d*, ♂; *e*, elytron.
Fig. 4. Phlepsius nebulosus. *a*, profile; *b*, face; *c*, ♀; *d*, ♂; *e*, elytron.

PLATE XXIV.

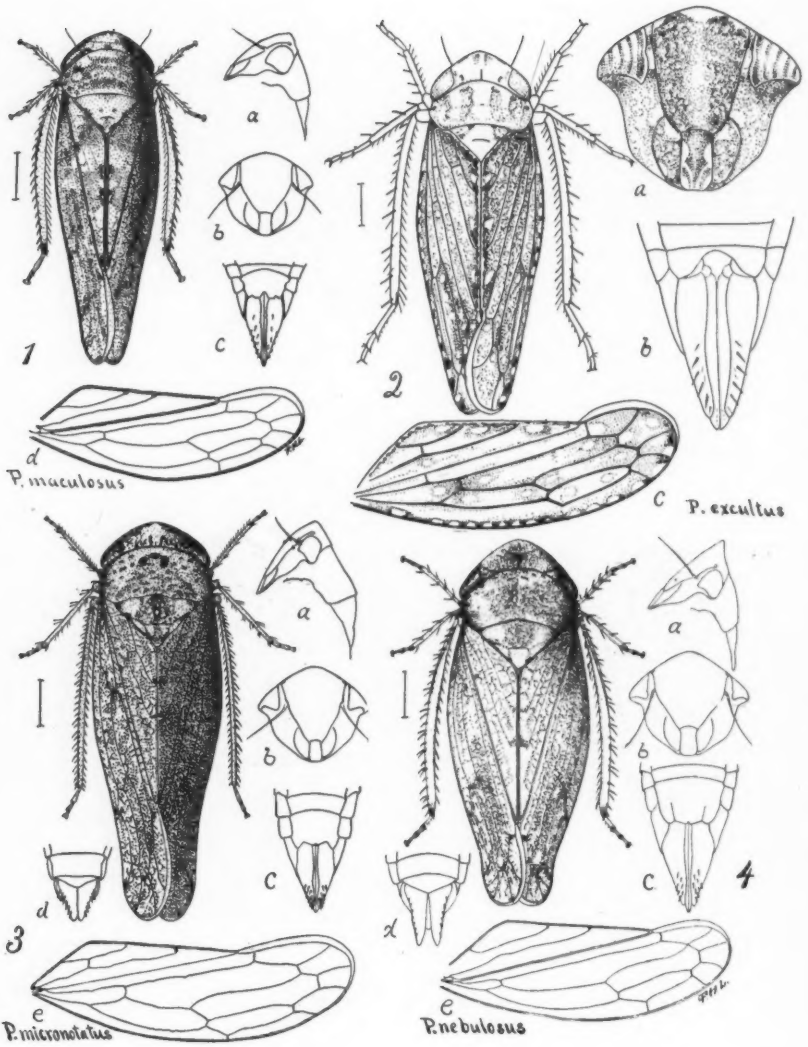
Fig. 1. Phlepsius lobatus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.
Fig. 2. Phlepsius areolatus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.
Fig. 3. Phlepsius eburneolus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.
Fig. 4. Phlepsius denticulus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.

PLATES XXV TO XXXIII.

In these plates cited in text, the name of each species is entered under the figures which show: *a*, dorsal view of head and pronotum; *b*, profile; *c*, ♀; *d*, ♂ genitalia. A detailed explanation is therefore unnecessary.



Osborn and Lathrop



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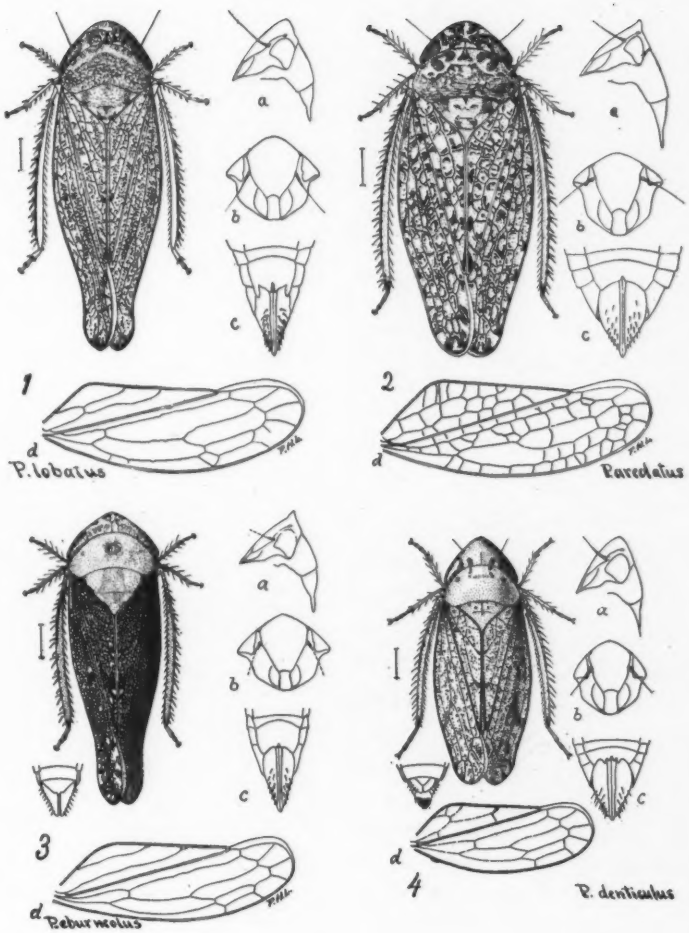

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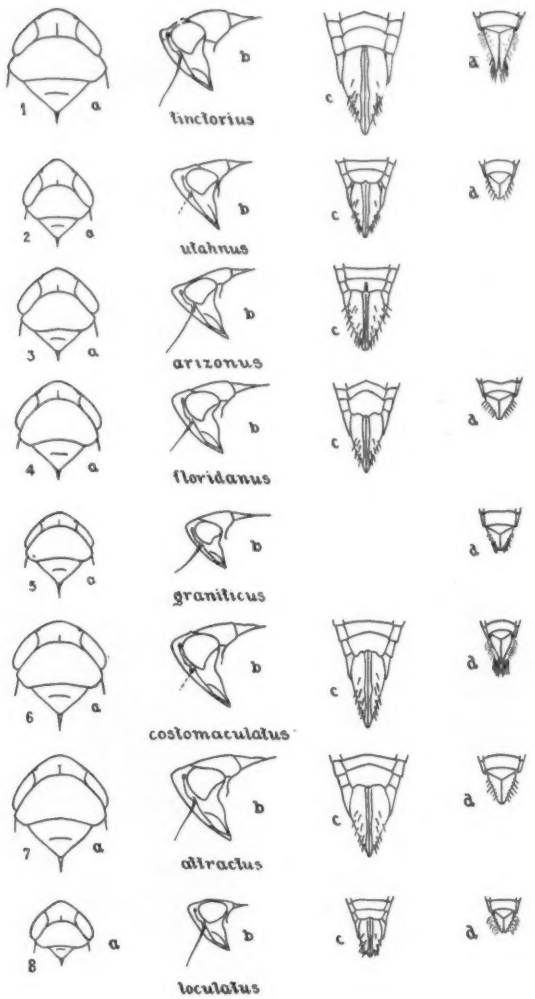

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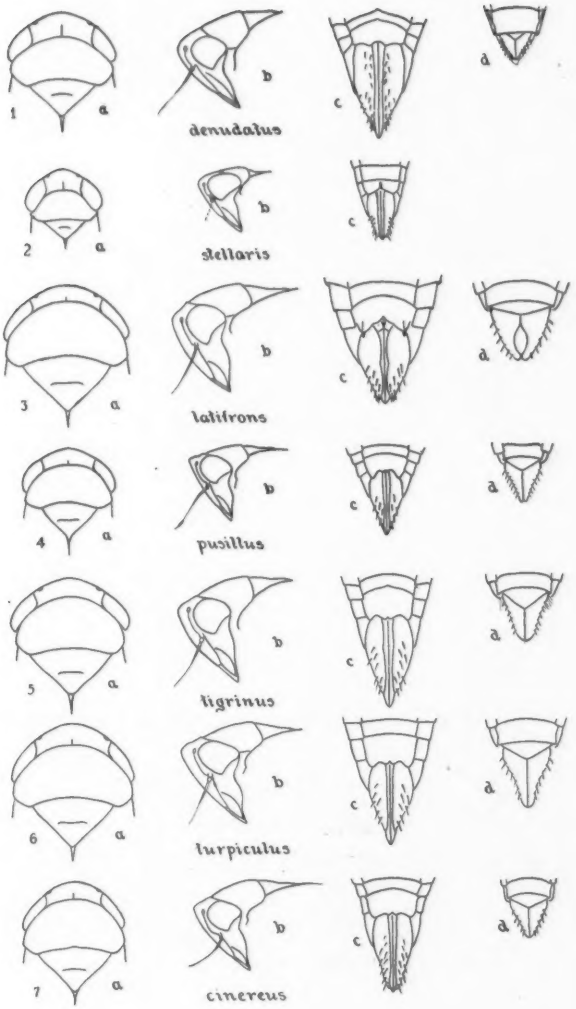

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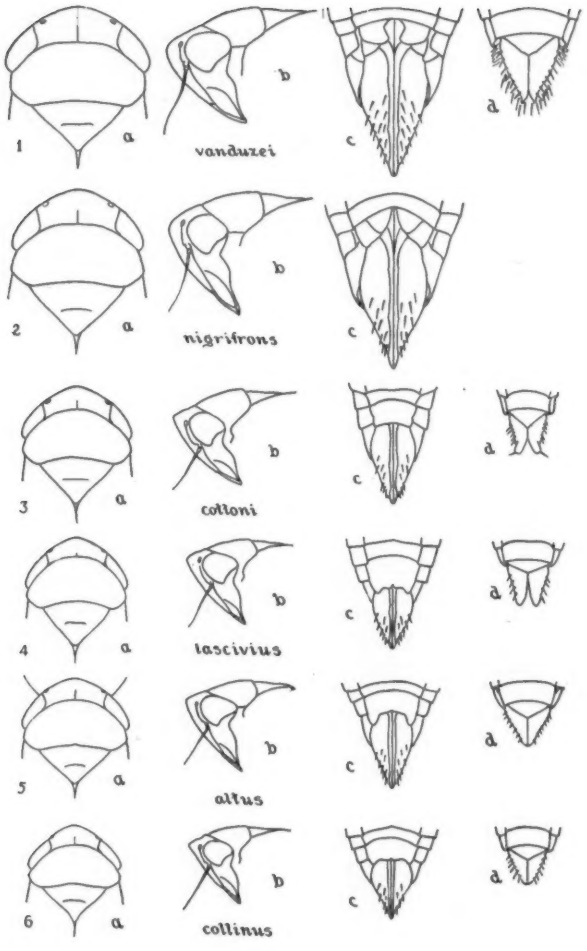

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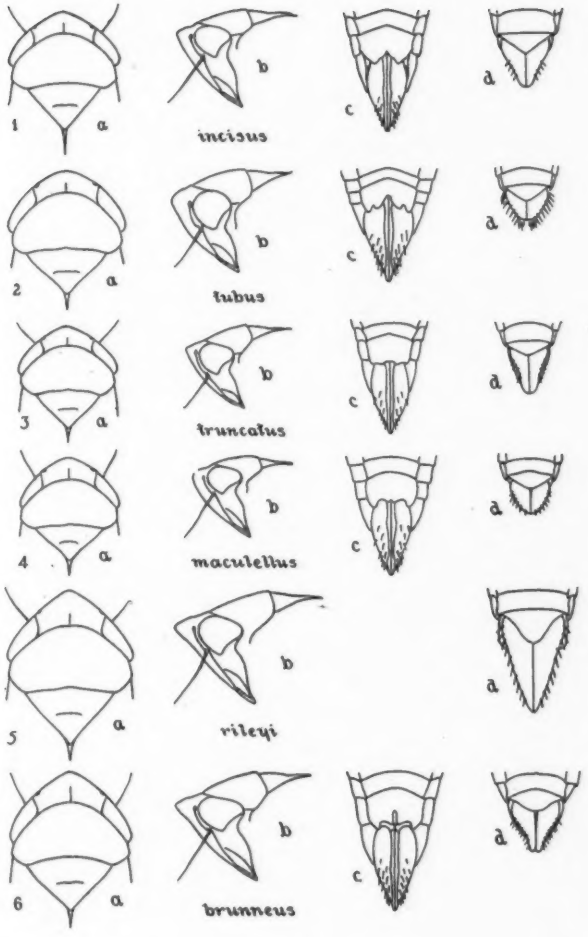

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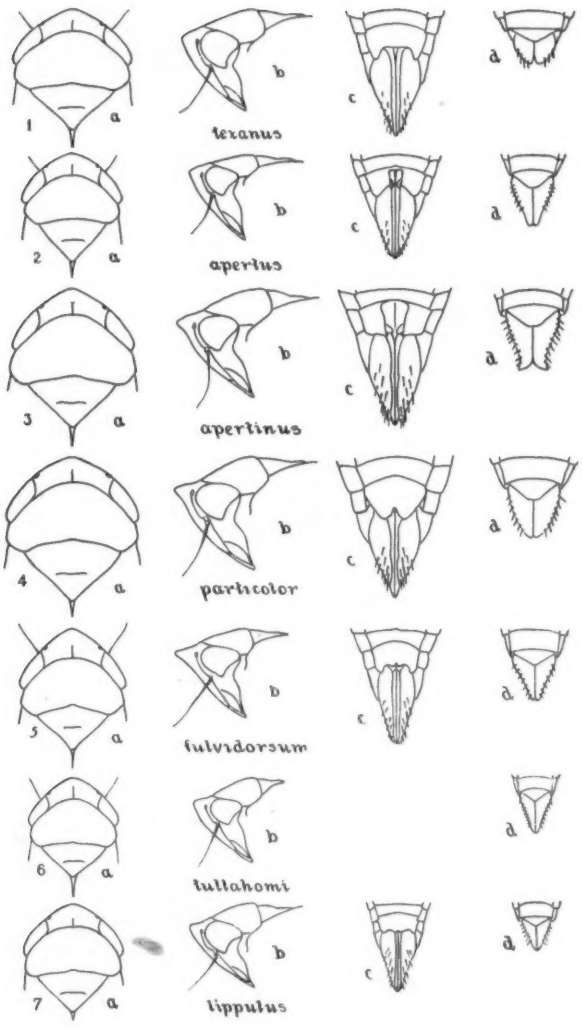

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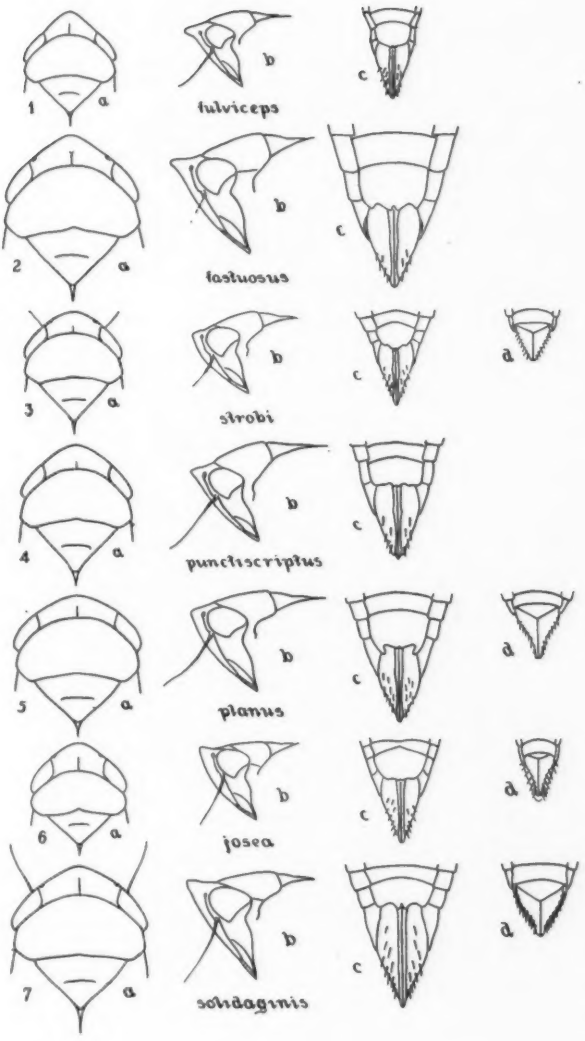

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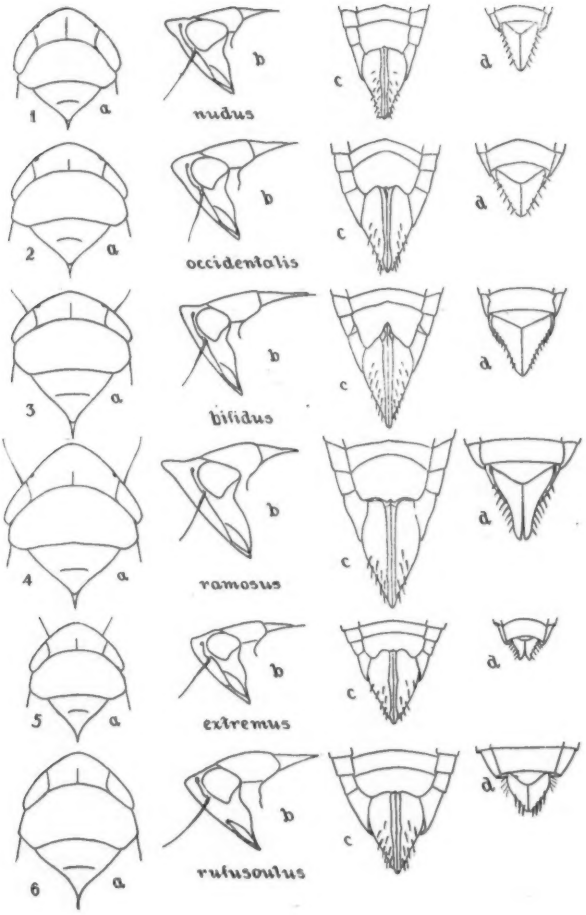

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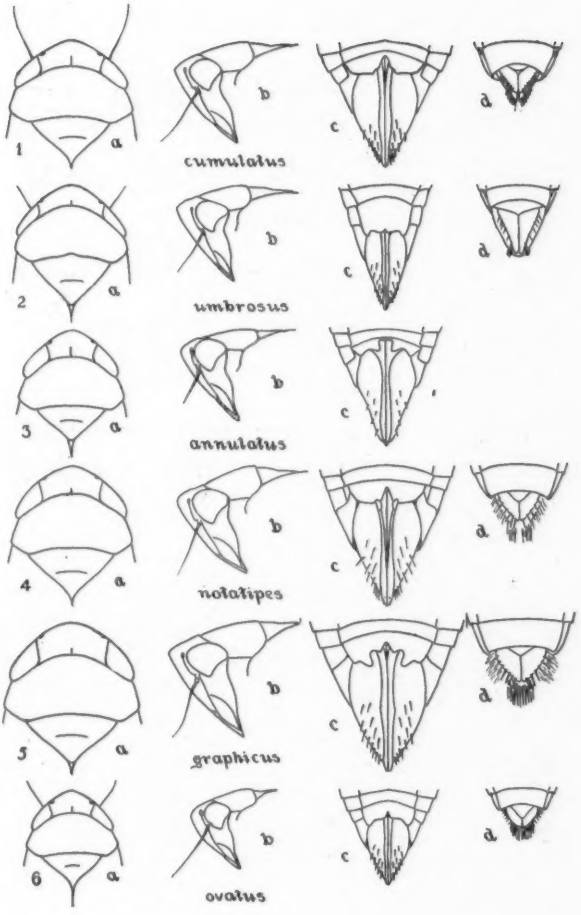
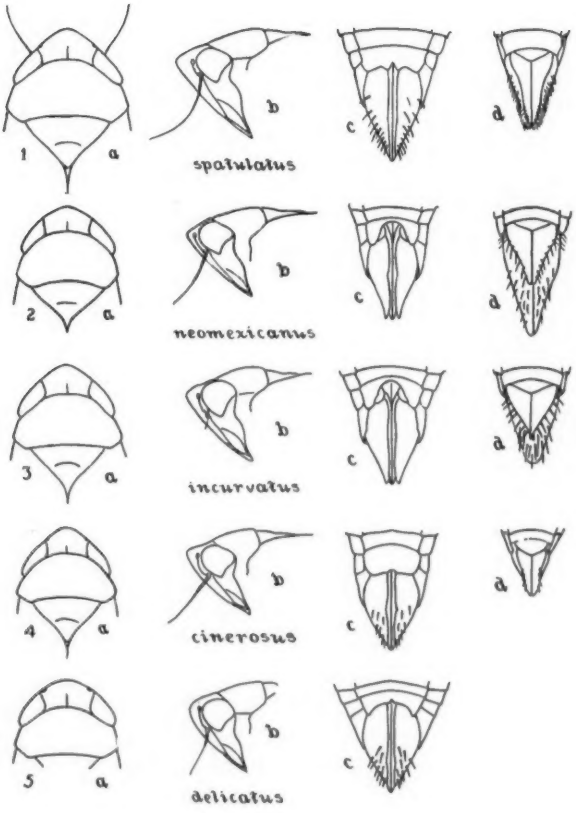


Osborn and Lathrop



Osborn and Lathrop

THE DISTRIBUTION OF THE LEAFHOPPERS OF PRESQUE ISLE, PA. AND THEIR RELATION TO PLANT FORMATIONS*

DWIGHT M. DELONG,
Ohio State University, Columbus, Ohio.

The relation existing between insects and plants and especially the synchronous changes in abundance and succession that accompanies changes in habitat conditions is of both interest and importance to workers in certain groups. It is interesting to know under what conditions an insect lives, and if the habitat and specific food plants are variable in different regions. But these data are usually very hard to obtain in disturbed areas as a complication of conditions and a mixture of food plants may occur. Presque Isle has furnished an ideal place for such a study because the zones and stages of plant associations, and their successions are so well defined. Consequently a record of specimens captured and a study of existing conditions there may be of interest to others.

The Island, or peninsula as it might better be called, is a projection extending some six miles north-east from the mainland at Erie, Pennsylvania, and is more than three miles wide at its broadest portion, the eastern extremity. The entire formation is the result of wave action, and since it has accumulated over a period of many years, all stages and conditions in plant successions of this region are found there. The older portion is covered with a deciduous forest, more recently constructed areas with pine forests, shrub stages, bog and heath, and the new portions with sand plains, dunes, marshes and numerous lagoons in various stages of succession. Although insects do not have such well defined successions of associations as do plants, they do have certain very definite relations with certain plant associations and as these constantly change from one stage to another, we find for the most part a different group of insects accompanying each successive plant association.

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*Contribution from the Department of Zoology and Entomology of The Ohio State University, No. 74.

The portion of this area which has been studied more thoroughly is the broad eastern extremity or sand plain area with its numerous lagoons and marshes in all successional stages. Some study was also made at the head where the peninsula connects with the mainland. Only a brief resume of these habitats will be given in the following pages together with their respective findings.

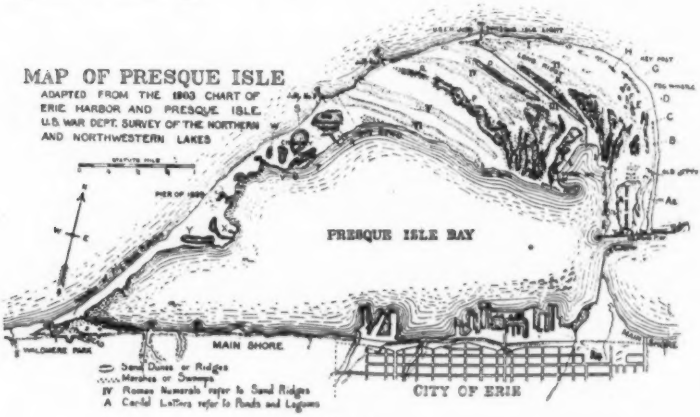

MAP OF PRESQUE ISLE
ADAPTED FROM THE 1903 CHART OF
ERIE HARBOR AND PRESQUE ISLE
U.S. WAR DEPT. SURVEY OF THE NORTHERN
AND NORTHWESTERN LAKES
PRESQUE ISLE BAY
MAIN SHORE
CITY OF ERIE

FIG. 1.
Map of Presque Isle, Pennsylvania, showing physiographic conditions.

A detailed study of the plants of Presque Isle has been made by Dr. O. E. Jennings and his excellent outline of the plant associations and successions has been followed in this report. Only the leafhoppers belonging to the Cicadellidæ (Homoptera) have been studied because of the author's familiarity with the group and also in order to obtain more specific results regarding their relationships to plant associations and formations. Although many other insects were collected in these habitats, no consideration is given to them at this time.

THE BEACH-SAND PLAIN-HEATH-FOREST SUCCESSION.

The beach is practically devoid of leafhoppers and although an occasional specimen of *Cicadula 6-notata* or some other cosmopolitan feeder may be found here, these are probably accidental records and the insects have no definite relationship to the meager vegetation that is able to withstand the storm and wave action.

The sand plain occupies large areas of the eastern extremity. The vegetation of the sand plain proper is very uniform and composed of a few predominant species. One of these grasses *Andropogon furcatus*, (a climax plant of the prairie) is abundant and usually found growing in clumps throughout this portion of the island (Plate XXXIV, Fig. 4). *Thamnotettix pallidulus* Osb. has been taken abundantly from this grass and seems to be restricted to it as a food plant. This is a western species described from Iowa in 1898. A recent citation from Kansas is the only record since its original description and it has not been reported previously east of the Mississippi River.

Large areas of scattered tufts of *Panicum* also occur on the sand plain (Plate XXXV, Fig. 3). Two species are especially abundant, *Panicum villosissimum* and *P. hauchucæ*, and are some what intermingled. Both of these appear to be food plants of *Deltocephalus apicatus* Osb. which was taken in abundance at various intervals during the summer both as adult and nymph. Other species commonly found on the sand plain are *Deltocephalus inimicus*, *sayi* and *misellus* and *Phlepsius irroratus*.

Dr. Jennings has shown that there may be a heath or a *Myrica* thicket association in the beach—forest succession. Where the *Arctostaphylos-juniperus* Heath Association occurs, only a few leafhoppers are found. *Gypona octolineata* and *rugosa* have both been taken from a uniform and pure society of *Arctostaphylos*. In case a Myrica thicket association follows the sand plain, another group of insects occurs. Such species as *Empoasca flavescens* and *Balclutha impictus* are found on the *Myrica*, *Graphocephala coccinea* is abundant as nymph and adult on species of *Rubus*, *Deltocephalus configuratus* on *Poa compressa* and usually *Empoasca atrolabes* and *Oncopsis variabilis* are always present on *Alnus*.

The *Quercus velutina* Forest formation has not been worked in detail for the leafhopper species. A few observations have been made however. Several species of *Erythroneura*, *Empoa* and *Empoasca* occur on *Quercus* and *Acer*. *Jassus olitorius* is apparently confined to Sassafras as its food plant. *Gypona pectoralis* and *Alebra albostriella* are very common on *Tilia americana*. *Erythroneura tricincta*, *vitis*, *vulnerata*, and *comes* are common on species of *Vitis*.

On the herbaceous layer many common species as *Scaphoideus immistus* and *auroniteus*, *Balclutha osborni*, *Deltocephalus*

sayi and *inimicus*, *Phlepsius irroratus* and *Cicadula 6-notata* are found. Other species less abundant as *Mesamia vitellina* live on the herbaceous vegetation and *Scaphoideus lobatus* was found as nymph and adult feeding upon *Solidago cæsia*.

The leafhopper species do not differ greatly from the preceding in the associations of the Dune-Thicket Forest Succession, undoubtedly due to the fact that about the same plants are found in these associations as those mentioned above. Many of the plants of the sand plain such as *Ammophila* and *Andropogon* are common on the dunes and numerous grass feeding forms mentioned above occur on these plants. Where dunes are built up by the cottonwood, *Populus deltoides*, the common poplar species are abundant, among which *Empoasca trifasciata*, *Idiocerus lachrymalis* and *I. suturalis* are usually present.

The *Rhus-Toxicodendron*-Thicket-Association is frequently so dense and entangled that it is very difficult to cut a path through it. Large areas of long ridge, especially, are covered with this dense growth. Several species of common insects were found in this habitat, many of them the same as those occurring on the sand plain.

THE LAGOON-MARSH-THICKET-FOREST SUCCESSION.

The areas by far the richest both in individuals and species are the moist areas in the marshes and along the lagoon margins. A great number of lagoons are present and represent all stages in development from a pool of clear water in the midst of a sandy expanse, bordered by practically no vegetation, to ponds of arrow weed and marshes entirely filled with sedges. It is surprising how these different types of lagoons will vary in their "Jassid" fauna.

The willows and poplars are apparently the first plants to come in at the margins of the lagoons. During their first few years no leafhoppers could be found upon them. Later, however, when the zones are greatly pronounced by the thick, shrubby growth, species like *Macropsis viridis*, *M. virescens var. graminea; Idiocerus pallidus*, *Empoasca obtusa*, and *E. flavescens* are found on the willows and *Idiocerus lachrymalis* is common on the poplar shrubs. Another group of plants which are submerged or float upon the water and belong to the *Potamogeton* Association begin to grow in the waters of the lagoon at about the same time. So far as records to date are

concerned, none of these insects are known to live upon the submerged or floating vegetation.

Lagoon Aa is comparatively young perhaps representing an early stage of the lagoon succession which is shown very definitely by the vegetation along the margins. A short tender growth of *Juncus*, *Eleocharis* and small segdes close to the water line furnishes ideal feeding places for *Phlepsius fuscipennis* and *collitus*, *Euscelis parallelus*, *striolus* and *cuneatus* and *Cicadula 6-notata* which are found in abundance on the short vegetation in the narrow zone along the lagoon margin (Plate XXXIV, Fig. 5). Only a few feet from the water line of the lagoon the sand plain vegetation is found and as stated previously, a different group of species is present.

Euscelis cuneatus a very abundant and recently described species lives in company with *Cicadula 6-notata* and *Euscelis striolus* on a uniform mat of *Cyperus diandrus* on a newly formed portion of the island (Plate XXXV, Fig. 4).

In the case of older lagoons such as C. D. and G. representing later stages of the lagoon succession where a wider margin of vegetation occurs, many sedges and grasses grow in the *Typha-Scirpus* and especially the *Sabbatia-Linum* association and several species of *Juncus*, *Eleocharis* and *Scleria* abound. Here we can add to the lagoon species already mentioned, *Thamnotettix melanogaster* and *fitchii*, *Dræculacephala mollipes*, *Helochara communis* and *Phlepsius irroratus*. A marshy area at the end of lagoon Aa contains *Chlorotettix spatulatus* and *Dræculacephala minor* in great abundance.

One of the most interesting captures was the securing of *Dorydiella floridana* in great abundance from *Scleria verticellata* in the *Eleocharis obtusa* association (Plate XXXV, Fig. 2). The nymphs were found feeding on the stems just above the surface of the ground and within the clump. This mode of living may explain the fact that this species is considered as very rare and has seldom been collected. Comparatively few specimens can be obtained with a sweep net but by pulling apart a clump of the sedge, frequently two dozen were secured from a single clump.

It was described in 1897 from Florida and although cited only twice in literature since it has been taken in very few numbers in Massachusetts, New Jersey, Illinois along Lake Michigan, and in a similar lake habitat in South Dakota.

Although found occasionally along the lagoon margin its optimum habitat apparently is on sandy areas far distant from the receding waters of the lagoon but within the old lagoon basin. The nymphs and adults were very abundant in this habitat during the past four seasons. *Phlepsius nebulosus* occurs in good numbers in the same type of place but apparently has a different food plant. *Phlepsius fuscipennis* and *Euscelis parallelus* are also very abundant in the old lagoon basins.

In lagoons E. F. and Fa representing the next stage there are only a few additions to the leafhopper species. More striking is the additional number of Fulgoridæ and Cercopidæ which are found here. Such species as *Pentagramma vittatifrons*, *Philænus lineatus* and species of *Stenocranus* are quite common during July.

Perhaps the last stage is presented by the middle one of the three marshy areas just north of Horseshoe pond. Although water is still found in the center of this old lagoon, it has become very shallow and is composed mostly of a black soggy soil. It is rapidly approaching a true marsh condition. Two rather interesting species were added here to our list of lagoon species. *Cicadula potoria* was living on a mat of very short, fine, *Eleocharis acicularis* (Plate XXXV, Fig. 1) and further study on the island showed that it lived apparently under no other condition. This species was living so close to the soggy black soil that it was almost impossible to sweep specimens into a net. It was described from Iowa by Ball, and Juncus was given as the food plant. It has since been reported from Maine and New York. The other species of interest is *Thamnotettix smithi*, which was abundant on a large patch of *Spartina michauxiana*, forming an outer zone in the same marsh. (Plate XXIV, Fig. 3). It is apparently a northern and western species and the food plant has not been mentioned previously. *Cicadula slossoni* a Juncus species is another addition in this association.

The marsh stage of the lagoon succession is shown by lagoon B and marsh 3 just north of horseshoe pond. Although a little clump of *Typha* still remains, the lagoon basin is almost entirely filled with *Calamagrostis canadensis* (Plate XXXIV, Fig. 1). This is the so-called wet meadow and a large group of species live upon these grasses. The most abundant species found here are *Chlorotettix unicolor*, *spatulatus* and *tergatus*, *Phlepsius irroratus*, *Thamnotettix nigrifrons* and *melanogaster*, *Parabolo-*

cratus major, *Dræculacephala mollipes* and *noveborocensis*, *Deltocephalus inimicus*, *striatus* and *sayi*. *Platymetopius frontalis* and *acutus*, *Mesamia vitellina* and *Scaphoideus ochraceous* occur less abundantly. Perhaps the most interesting species occurring here are *Thamnotettix inornatus*, *Deltocephalus osborni* and *Dikraneura mali* which species do not occur on other plants on the island and are apparently restricted to this habitat. So these may be added to the species of the lagoon succession. In the wet meadow at the west of horseshoe pond *Cicadula pallida* and *Euscelis elongatus* were taken from short grasses in the marshy area (Plate XXXIV, Fig. 6).

A detailed study of these lagoons in various stages has shown that as the vegetation constantly changes in the older lagoons, new species of leafhoppers also work into the association especially where restricted to a single plant for food. The change is perhaps not so pronounced nor so permanent as in the case of the plants, but is nevertheless a different association.

THE BAY-MARSH-THICKET-FOREST SUCCESSION.

At the head of the peninsula between the narrow neck and the mainland, a large and very interesting swamp area is fouud with small patches of marsh and wet meadow at its margins. In this swamp on the *Typha-Scirpus* association, large numbers of *Dræculacephala angulifera* both as nymphs and adults occur on *Scirpus fluviatilis*, the river bulrush (Plate XXXIV, Fig. 2.) Also a large *Cicadula* (apparently undescribed) was present in abundance.

On the *Carex-Phragmites* association which merges with the wet meadow a large number of species of leafhoppers are found. The principal species here are *Dræculacephala mollipes*, *Chlorotettix unicolor*, *Thamnotettix fitchii*, *T. melanogaster* and *Phlepsius solidaginis*. The number and dominance of species, however, will vary with the season and the consequent life cycle. Other common species found here in more or less abundance during the summer are *Platymetopius frontalis* and *P. acutus*, *Euscelis striolus*, *Deltocephalus inimicus*, *D. striatus*, *D. balli*. *Phlepsius irroratus*, *Agallia 4-punctata* and *A. sanguinolenta*. During certain months *Thamnotettix cypraceus* is abundant as nymph and adult upon sedges in a grassy-*Solidago* association which is intermediate between the true wet meadow and the shrub zone. Also *Scaphoideus immistus* and *S. auronitens* are found

here. Several specimens of *Deltocephalus configuratus* were taken from *Poa compressa*.

Where the wet meadow is being invaded by the *Rhus-Alnus* shrub association other leafhoppers are found. Such species as *Oncopsis variabilis*, *Alebra albostriella*, *Empoasca atrolabes* and *Empoa tenerrima* are common and abundant upon *Alnus*.

The *Ulmus-Acer* association was not worked in detail for leafhopper species but two rather interesting observations were made. Where *Solidago cæsia* is found as a member of the ground layer, *Scaphoideus lobatus* was collected in abundance both as nymph and adult. Also on the *Linden*, *Gypona pectoralis* and *Alebra albostriella* were abundant. On the dunes and sand ridges where the poplars form an important part of the vegetation such species as *Idiocerus lachrymalis* and *I. suturalis* are abundant on *Populus deltoides*. *Idiocerus cognatus* is very common on *Populus alba* and the Lombardy poplar is apparently the food plant of *Idiocerus scurra*.

Where the *Salix* shrub zone follows immediately the *Scirpus americana* formation certain species are found feeding upon the willows. *Macropsis viridis*, *M. suturalis*, *M. virescens var graminea*, *Idiocerus pallidus*, *I. snowi*, *I. suturalis*, *Empoasca obtusa* and *E. smaragdula* are the principal species. Also *Empoasca flavescens*, *Thamnotettix clitellarius* and *Eutettix seminudus* are found in less abundance.

This study has been especially interesting for three reasons. First, because the vegetation is arranged in such a way as to give definite zonation, and great extremes of conditions are found in limited areas. Second, several interesting and valuable records of supposedly rare species have seemed to strengthen the theory that a species is considered rare only when its food plant is very scarce or more often when its habitat and mode of living are not known. Third, by studying a group of insects which are plant feeders and by taking only this one group with which study has been carried on for several years, more detailed results were obtained than in the case of a study of all insects or all animals present in a definite habitat, for frequently there is a failure in such cases to distinguish between valuable records and those of minor importance.

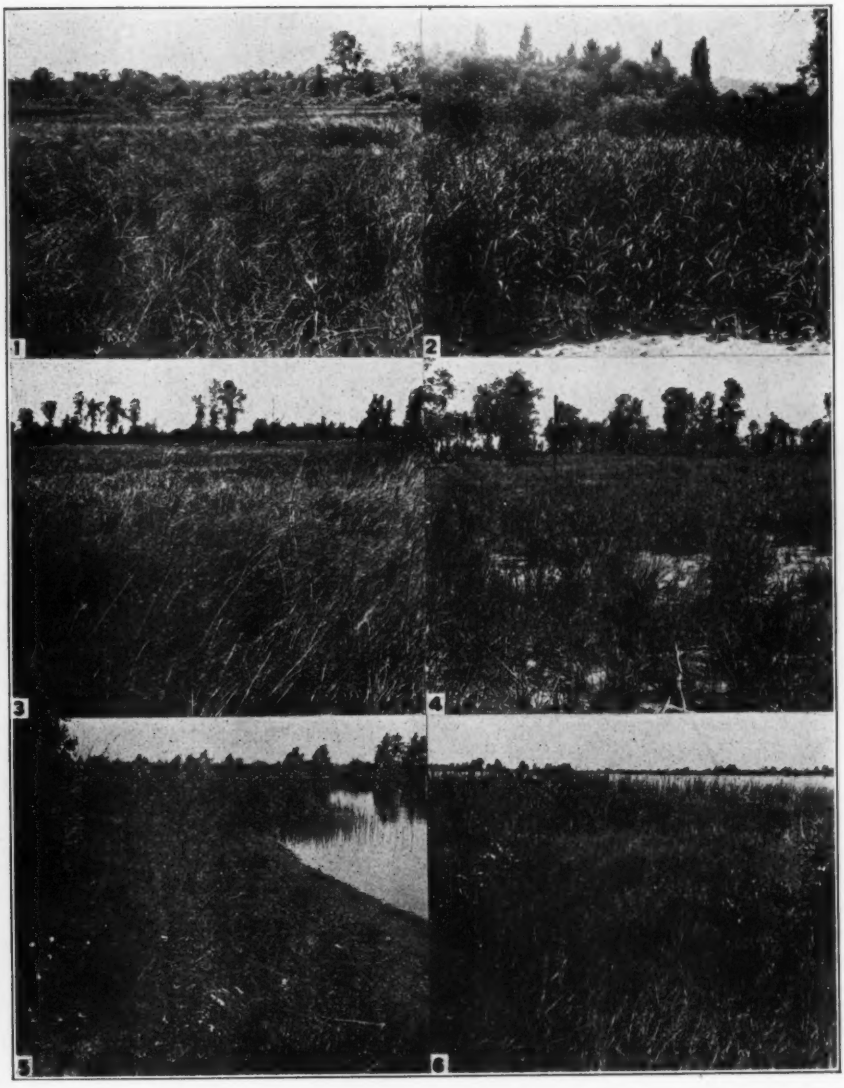
EXPLANATION OF PLATES.

PLATE XXXIV.

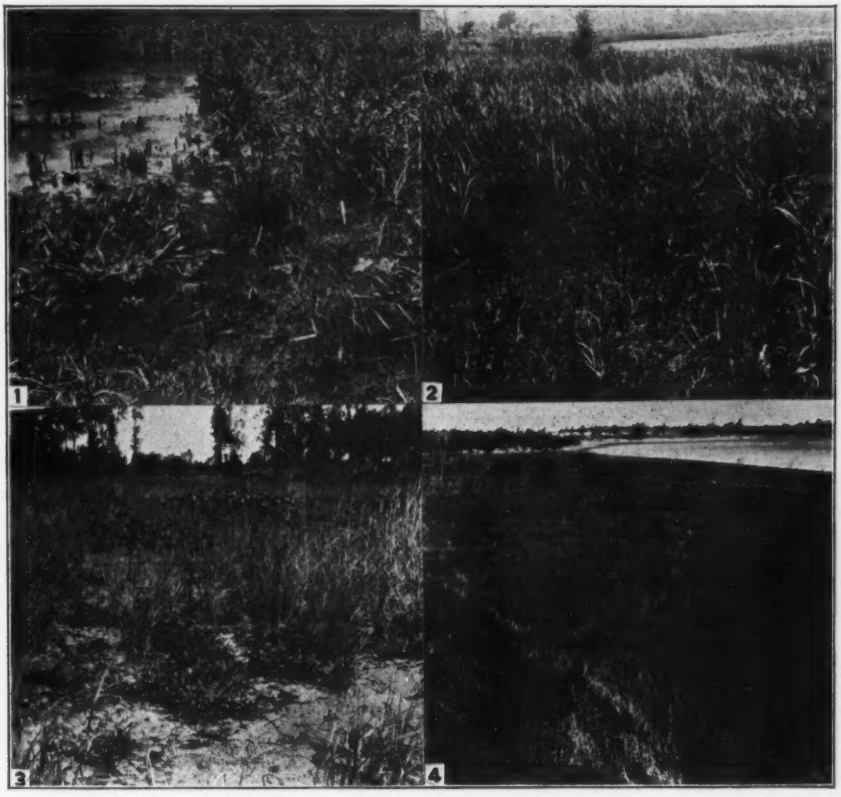
1. Wet meadow filled with *Calamogrostis canadensis*.
2. Association of *Scirpus fluviatilis* with *Salix* shrub zone in background.
3. Association of *Spartina michauxiana* in forground, habitat of *Thamnotettix smithi*.
4. Sand Plain showing *Andropogon furcatus* association, food plant of *Thamnotettix pallidulus*.
5. Lagoon Aa showing short growth of *Juncus-Eleocharis* along margin.
6. Marshy area along horseshoe pond, showing *Typha-Scirpus* zone, also wet meadow with mixed vegetation containing young willows.

PLATE XXXV.

1. Marsh area with *Eleocharis acicularis* association.
2. Association of *Scleria verticillata* and *Eleocharis obtusa*.
3. Sand plain showing patches of *Panicum villosissimum* and *P. hauchucae*, food plants of *Deltocephalus apicatus*.
4. Association of *Cyperus diandrus*.



D. M. DeLong



D. M. DeLong

OBSERVATIONS ON THE BELLURA

By Ellen Robertson-Miller.

In the early days of my insect study Professor Comstock told me about an odd caterpillar, *Bellura gortynoides*, which lives in the leaf-stems of the yellow water-lily, *Nymphæa advena*. He called it the Diver, because of its peculiar habits.

The insect interested me, and as I found little had been written about its life history I determined to make a personal study of the creature.

On the 3rd of the following October, at Myers Lake, near Canton, Ohio, the opportunity came to begin this work. B. V. and I were in a boat collecting aquatic material when she noticed a yellow lily leaf that had a hole in its surface directly above the petiole and opening into it. She pulled up the stem, and with such force that a dark, oily-skinned larva, some 4.5 cm. long landed on my knee.

I knew that B. gortynoides caterpillars had been reported from lakes where the yellow pond lily, Nymphæa advena, grows, while *B. melanopyga* was said to live on Nymphæa americana. Only advena is at Myers Lake, so I concluded that our find must be B. gortynoides, the Diver. We began searching for tunneled petioles, and found many, but the greater number were empty.

A kind of turret—the frass of the larva—about the opening on the leaf usually indicated that a Bellura was living below; but we soon discovered that the gallery in a stem might extend through its entire length, and if occupied the larva would "dive" to the bottom of its burrow if it felt its home disturbed. Several caterpillars escaped in this way before we learned that we should pick long stems to secure the inmates.

However, we secured six specimens, all nearly of a size, and by placing the inhabited leaves and plenty of fresh ones in a tub of water we gave the larvæ as nearly natural conditions as was possible, and left them until the following day.

I then removed and examined one of the caterpillars. It measured 5.5 cm. in length, its color on the dorsum, a dark drab, gradually became a light yellowish gray on the ventral

surface. The dorsal half of the twelfth segment seemed to have been sliced away, leaving exposed a posterior area on the eleventh segment, where the caudal spiracles, transposed from their normal side position, were located. These were larger than the other spiracles.

This specialized breathing arrangement for Bellura caterpillars may have required long years for its perfecting, but how clever it is! A larva can stay concealed all day in the stem of its water-plant, just backing to the entrance when its air reservoirs need refilling, or it can remain submerged for hours, as I discovered later, because of the size of these reservoirs.

The head of the caterpillar was a light chestnut-brown. On either side and close to the adfrontals on the epicranial lobes there was a small crescent-shaped pit, one tip of which became a gray ruga extending toward the vertex. Other rugulæ crossed the frons and cheeks somewhat horizontally, and as I learned later, they are less pronounced on gortynoides than those on the head of Arzama obliqua (Bellura obliqua), and are slightly different from those on Bellura melanopyga. The clypeus was lighter than the frons. The frontal suture was peculiarly waved, and I have found this a characteristic feature of B. gortynoides. The frons was stalked.

The antennæ were light, except for a dark encircling mark where the joints came together, and for the dark terminal joint.

The eyes, six in number, were arranged five in a semi-circle and the seventh back of the lower one. The three in the center were pigmented, the others lacked color. The thoracic shield was dark, and there was a dark spot on each of the prolegs, those on the anal claspers being pear shaped. The spiracles, normally placed excepting on the eleventh segment, were outlined in a lighter shade than that of the body color.

Two days after finding the larvæ we saw that all had made galleries in fresh stems. The larvæ ate the green tissues of the leaves usually at night, and they never remained long exposed after a meal.

By the 10th of October two of the caterpillars had stopped eating and I assumed that they were preparing to pupate.

Because of the ease with which these Belluras swam through the water I thought they might pupate on shore in the ground, so I partly filled a can with damp sterilized earth and placed the larvæ in the can, covering it with a sheet of glass. Within

ten minutes one crawler started digging into the earth and was soon entirely concealed. There it remained for three days. Then I saw a second larva burrowing, and as it disappeared the head of the first one, followed by its body, reappeared and began moving about in a very lively manner. I replaced the glass and left the caterpillars to adjust their difficulties.

They went back into the earth and three others followed their example within a few days; but the sixth larva fed until the 8th of November, when, there being no more food leaves, I dropped it into the can and saw it disappear as had the others.

Two weeks later I carefully removed the dirt from the can, expecting to find the caterpillars changed into pupæ; this was not the case, however. Instead there were four larvæ, each curled in its separate cell. They were in good condition and when disturbed grew quite lively. But what had become of the other Belluras? Were they eaten by their companions? The can had remained closely covered and undisturbed.

I left it out in the cold until December, when I again opened it and saw a larva resting exposed on the dirt. A little probing disclosed a second crawler safe in its underground cell. I did not investigate farther at the time, but late in January I saw that the exposed caterpillar had died from a white fungus that was in possession of its body.

Little by little I removed the dirt from the can. It was still damp and molded largely into irregular pellets. I located one oval cell 22 mm. long, with walls slightly cemented. It was intact but empty, and there were no caterpillars where six had been.*

Larvæ thought to be B. gortynoides had been found at Ithaca, N. Y., under the bark of an old post at the water's edge, so late the next April I was at Myers Lake searching for hibernating caterpillars. I found three. They were in oval cells under the bark of old, damp logs, but the logs were not submerged. The cell had been bitten out of the wood by the insect and the particles of wood fiber pushed back so that they formed a wall around its body.

These caterpillars had darker heads than those found in October and the sculpturing on the faces seemed to me, even then with my lack of experience, different from that which I had seen on the lily-feeding larvæ.

*Later experiences with Bellura larvæ lead me to conclude that they are cannibalistic under certain conditions.

In time two of the crawlers developed into moths, a male and a female, and were identified as *Arzama obliqua* (Bellura obliqua), a species which is found living and usually pupating in cattails, *Typha latifolia*, and with which I was somewhat familiar through information sent me by Mr. Charles Rummel, of Newark, N. J. The third caterpillar died.

Early in June I examined moths taken by a friend at Congress Lake, near Canton, with the hope that I might find among them a B. gortynoides. I did not, but there was an Arzama obliqua pinned to a mounting-board. She had revived after being placed on the board and had laid eggs in a kind of silken nest formed by threads of mammalian glue exuded with them. The mass suggested a spider egg-case, and it was this case that led me to look on the Nymphaea leaves for similar cases, which might prove to be those of B. gortynoides.

The next day, June 12, at Myers Lake, B. V. and I discovered them, three egg masses, each on the upper side of a Nymphaea leaf. They were irregular in form and one was much more silky than the others.* I measured an egg mass. Its base dimensions were approximately 8 mm. by 3 mm. As I did this it became detached and slipped from the leaf.

This accident enabled me to see the underside of the eggs. They had been laid in a flat mat of twenty and were small, the individual egg being but .9 of a mm. in diameter. It was hemispherical, pale amber in color, and through a binocular microscope the surface was seen to be finely pitted, giving it a slightly granular appearance. After the eggs hatch the shells lose this color and become a dirty white on the outside, but show a pearly inner surface.

On June 15th minute gnawings of the green leaf-tissue were in evidence about an egg mass, and a day later I saw fine runways radiating from the nest. The larvæ were eating the green chlorophyl-bearing tissue of the leaf. The young caterpillars entered the leaf as near their shells as was possible, and the shells soon after loosened and disappeared.

When I found that the eggs were hatching I probed among them and removed a tiny larva. It had a light body, tinged

*I have learned in later years that freshly exuded eggs are covered by silvery white threads, but that these soon mat into a gray parchment-like covering that in color, texture and size suggests the cocoons of certain small Gyrinidae beetles that are attached to water-plants.

with green, and there were a few dark hairs on the skin. The head and the shield were brown and the caudal spiracles could be readily located. With the first molt the head and shield became a lighter brown and the body of a glassy cream color.

The weather was hot, I was rearing the larvæ some distance from where their food-plant grew and I found it difficult to keep the lily leaves fresh. So I put a section cut from a lily root, with a few young leaves attached, in a globe of water and placed the decaying leaf with its Bellura family upon it. Four of the semi-helpless caterpillars (they were molting for the second time) survived, and they ate so much that by the middle of July every leaf had been consumed and the stems tunneled.

In maturing the caterpillars changed to a grayish-yellow, and when 3 cm. long began burrowing in the stems.

As I could obtain pickerel-weed (Pontederia cordata) more readily than Nymphaea leaves, I placed it in the globe and the Belluras began feeding at once.* And after that they ate the leaves of one plant as readily as those of the other.

A single larva occupied a stem and always entered it at the top through the leaf surface, but in the open, I have found stems entered from the side.

At the end of July the caterpillars averaged 4.5 cm. in length, but they were not so dark in color as those taken in October.

I had supposed B. gortynoides to be a single brooded insect and was surprised on August 8th to find two of the larvæ shortened for pupation and a third already in its pupa form. This pupa, in the upper part of a tunneled stem, was slender, slightly curved, .25 cm. long and of a deep brown color. The eleventh segment of the pupa retained the caudal spiracles, and was also ornamented by a pattern on the dorsal side done in graceful lines, which looked as if they had been "tooled" on the surface, while the surface was soft and pliable.

It was not the only segment with special decorations, however. The eighth, ninth and tenth each bore a decided ridge, finely toothed and divided into dorsal and side scallops, while on the twelfth there were two pairs of sharp, stiff spines that curved backward and upward.

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* Bellura and possibly Arzama larvae are found in stems of P. cordata.

A female moth emerged from this pupa on August 20th. The front wings were like pale gold, with purplish-violet markings across them. The antemedial line was slightly dentate, the postmedial line decidedly dentate and excurved from costa to vein 4. The sub-terminal line was dentate, darker than the other markings and so curved that it made three scallops in the gray-lilac terminal area. The reniform in the wing was yellow, but scarcely discernible, and a rather wide band of the purplish-violet crossed the wing midway of its length and bent near the center so as to form an acute right angle.

The gold of the hind wings was suffused with rose madder, and this color largely obliterated the markings except for the pale yellowish outer border. On the under surface, the front wings were irrorated with pinkish-violet, quite pronounced in the terminal area, and this color was carried across the lighter hind wings in a curved line, and there was a dark discoidal spot in each under wing.

The body and the tufted thorax had the golden color of the fore wings and there was a bunch of shining white caudal hairs on the abdomen, indicating, according to Hampson, that the moth was Bellura gortynoides. The beautiful white of these hairs, which is so noticeable when the moth emerges, soon become dull and less conspicuous.

This moth was the only adult reared from the eggs found on June 12th, but B. V. had mailed me several pupæ, each in burrowed Nymphaea stems, and a few mature larvæ. One of the latter pupated within the rolled edge of a lily leaf on August 17th and yielded a male moth.

August 23rd I found him resting with wings held in roof fashion and the tip of his dark-pointed abdomen extending from beneath. The thorax was well tufted, reddish and deepening in tone toward the head. This color irrorated the wings, whose maculation was similar to that of the female except that the reniform of light orange was well defined.

At Myers Lake I saw no moths of this kind, but there were empty pupa-cases in the lily stems, and with some of these there were puparia of a fly identified by Dr. Aldrich as Masicira senilis, a parasite that deposits living maggots, which prey upon Bellura caterpillars.

I located egg nests but nearly all the shells were empty. I failed to carry larvæ from the eggs through to the adult period, and this has been my experience in more recent years.

The larvæ hatched from late summer eggs I reared separately after they entered the Nymphaea stems, and I gave each a can of sterilized earth or a piece of damp sterilized wood with bark on, in which to hibernate. They used both, but in only one instance was a pupa formed. This was on April 27th, and the insect was alive on May 18th. On May 21st it remained inactive, and I noticed white fungus between the segments. I removed the moth—perfectly formed. I could see the bunch of caudal hairs, but I could not determine the markings of the wings.

Is B. gortynoides seasonally dimorphic? Why are the moths so difficult to find in the open?

Late last September I discovered three Bellura caterpillars in a Nymphaea root; one had entered at the attachment of the leaf. Is it possible that these caterpillars winter in the roots of their food-plant, reaching them through the tunneled stems? I am inclined to think it may be so since reading Dr. P. W. Classen's interesting account of Arzama obliqua, in which he says its larvæ are found in closed cells in cattail during the winter, completely surrounded by ice, and that they pupate in these cells.*

But if Nymphaea roots are used for hibernation where do B. gortynoides pupate? Mature larvæ are never seen in the early spring.

OBSERVATIONS ON BELLURA MELANOPYGA.

On November 11, 1921, at Eustis, Florida, I found a group of eggshells on a leaf of *Nymphaea americana*. The eggs had been placed in a pile and they were covered with gray mammalian glue. The individual egg was white, opaque and semi-spherical in shape. The mass covered an irregular surface of about 3 mm. by 4 mm., and resembled the old egg masses of B. gortynoides found on Nymphaea at Myers Lake.

A well-grown B. melanopyga larva taken from a Nymphaea stem had a deep gray color with the posterior edge of the segments darker. This gave to the insect a slightly banded

* Typha Insects: Cornell University, Memoir 47.

appearance. The under side of the body was light. On the anal claspers there were four black tubercles, a hair arising from each, and on the caudal tip six tubercles. The claws were very dark.

The head was not deeply rugosed, the sculptured lines flowed downward from the vertex, much as they do in A. obliqua, but they were shorter. The frons was light brown and was crossed by four broken horizontal grooves. The frontal suture was dark brown. The adfrontals were like the frons in tone, and were distinctly set off from the epicranial lobes by a light line.

Other larvæ of about the same age had skins so dark that no banding was discernible on their bodies.

At the same time I collected pupæ. Each rested at the top of a burrowed leaf-stem.* The pupa cases were a dark brown. The caudal spiracles were not so conspicuous as are those of B. gortynoides, and the posterior ridges of the segments were not so ridged or toothed. The anterior portion of a pupa was rough, and on its vertex was a double tubercle.

On December 1st the first adult—a female—emerged. The color of the moth was a light ocherous-tan, with markings of purple-brown. The maculation was similar to that of the female B. gortynoides only the colors were not so brilliant, and the tuft of hairs at the tip of the abdomen was quite dark. Later this color became faded. The moth was identified as B. melanopyga by Mr. Foster H. Benjamin.

On December 15th a male moth emerged. The head and thorax were of a brownish-ochre, the head much the darker, but the abdomen showed little of the brown color. The fore wing was golden-ochre, marked and irrorated with brown madder—most thickly on the median space. The antemedial line curved and was minutely waved. The postmedial line was dark, dentate, excurved, then oblique to the inner margin. The subterminal line was minutely waved, excurved below vein 7 and at the middle, then it bent outward to tornus. There was a fine dark terminal line and the terminal area was of a gray-violet color.

The orbicular and reniform were golden-ochre and conspicuous in an area darkened by madder brown. An oblique

* I find pupae of B. gortynoides lower in the stems.

line of this color extended from the median cell to the inner margin. The hind wing was red ochre on its upper surface; but little of the red showed on the lower surface except in a wide terminal band and as a dark discoidal spot.

A goodly number of moths were secured. They varied slightly in color and in intensity of markings. The males were always the more beautiful, and they resembled so closely the female B. gortynoides that I was not surprised when Mr. Benjamin, who kindly examined and identified my Bellura and Arzama material, wrote that he was unable to separate the male moths of melanopyga from the males of gortynoides in the Dr. Barnes collection, and that my Eustis males might belong to either species. But as larvæ from which the male and female moths developed came from the same habitat, and as only Nymphaea americana grew there—the food-plant of melanopyga—it seems logical to conclude that the males belonged to the same species as the females.

Dr. Paul S. Welch has made a careful study of the habits of the larvæ of B. melanopyga, which are recorded in the University of Michigan Biological Bulletin, No. 2, Vol. XXVII. He did not find eggs, but very young caterpillars mining and feeding in the lily leaves.

The specimens which I took at Eustis were well-grown and they had reached what Dr. Welch calls the petiole period. Because of what I learned of the insect through Dr. Welch and through my own observations of melanopyga and of gortynoides, I conclude that the two species of Bellura are very similar in behavior as well as in appearance.

EXPLANATION OF PLATES.

PLATE XXXVI.

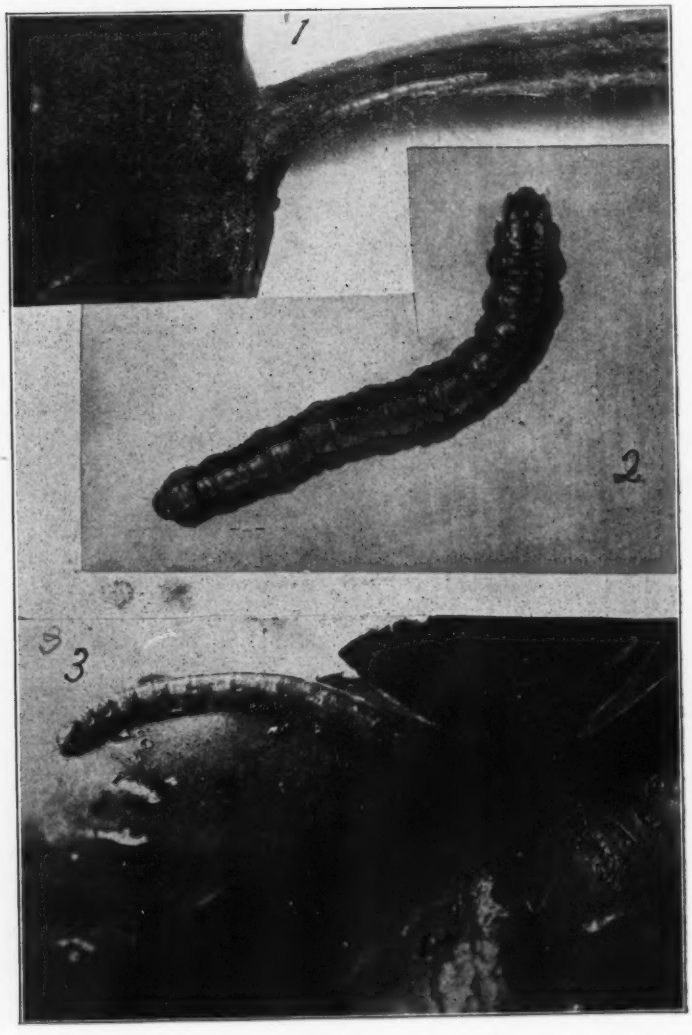
1. A young, light colored B. gortynoides larva, life-size, in the stem of the leaf. On the surface of the leaf three runways made by the small mining caterpillar are to be seen.
2. B. obliqua larva. Length 5 cm.
3. B. gortynoides larva on Nymphaea leaf, and the opening to its burrowed stem.

PLATE XXXVII.

4. Female B. gortynoides moth. Spread 40 mm.
5. Male moth of B. gortynoides. Spread 34 mm.
6. Egg mass of A. obliqua. 7 and 8—Egg nests of B. gortynoides. One showing the minute gnawings of the larvae. (Slightly Enlarged.)
9. and 10. Female and male Arzama obliqua moths, life-size, which developed from larvae found under bark June 1st. ♂ had a white tip to abdomen.

PLATE XXXVIII.

11. Egg mass of B. gortynoides. Base dimensions approximately 8 mm. by 3 mm.
12. Tenth, eleventh and twelfth segments of B. gortynoides pupa, showing the scallops and tooling.
13. Pupa of B. gortynoides.



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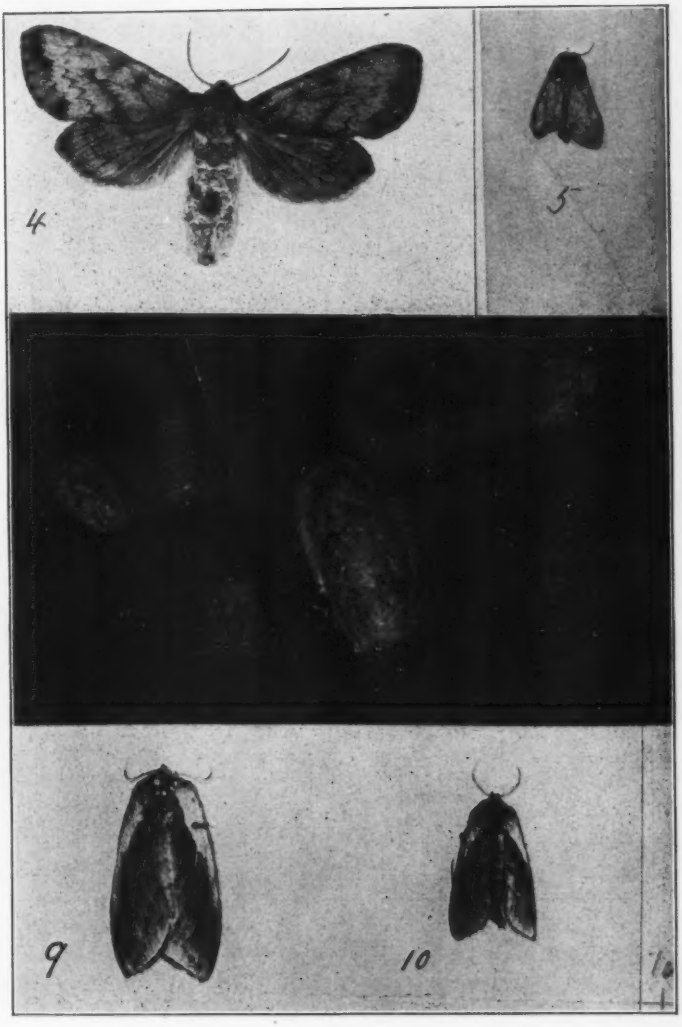

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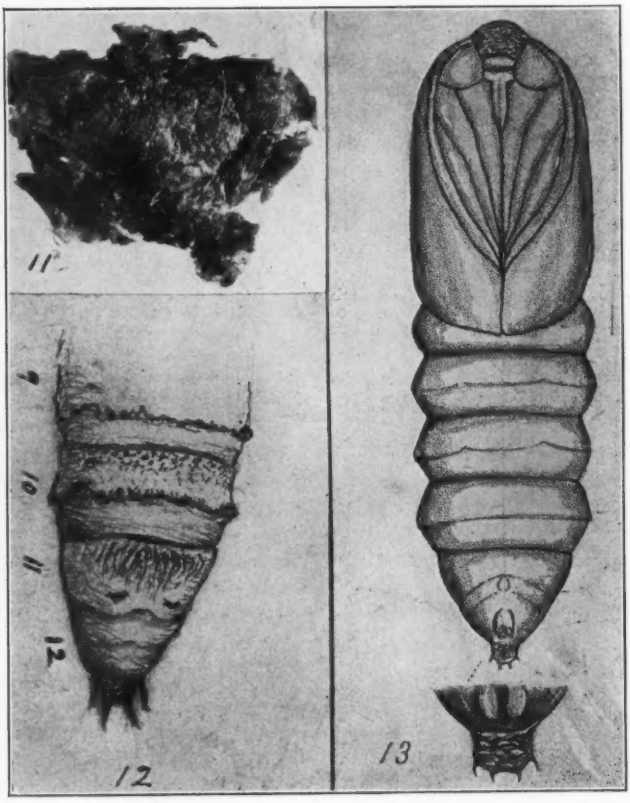

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HOLOSIRO ACAROIDES, NEW GENUS AND SPECIES,—THE ONLY NEW WORLD REPRESENTATIVE OF THE MITE-LIKE PHALANGIDS OF THE SUBORDER CYPHOPHTHALMI

By H. E. Ewing,
Bureau of Entomology, U. S. Department of Agriculture.

During the spring of 1912 while collecting insects and mites in the foothills of the Coast Range Mountains in western Oregon a number of small mite-like arachnids were observed on the moist soil under a small log. When first seen they were taken for Gamasid mites, and not being particularly interested in the family Gamasidæ, the writer picked up only two specimens. Later after reaching the laboratory, greatly to my surprise, I found that what I had taken for mites were not mites at all, but were mite-like phalangids, more mite-like apparently than any of the phalangids yet described.

Of the two specimens taken, one proved to be a mature female, and the other apparently an immature male. With only this scant material at hand it was deemed best to wait until further specimens could be obtained before attempting any description of the species. My search for other specimens, however, proved vain. On several occasions the same identical spot in the foothills was visited and searched but not here or at any other place among the scores of localities visited the next three years was a single additional specimen found.

Several years having now passed and in the meanwhile, the writer having come to the city of Washington some thousands of miles away from the scene of the capture of this interesting arachnid, the probability of never being able to take any more specimens appears imminent. Because of this probability it appears best now to record the discovery and to describe the arachnid that was found.

As will be seen by observing the figure (Plate XXXIX) of the phalangid, the abdomen shows no evidence of segmentation above; the legs are short and seven segmented; eyes are absent; and a single claw terminates each tarsus.

It should be added, however, that while the adult shows no evidence of abdominal segmentation above, the immature individual shows eight segments dorsally. It should be stated though that the immature specimen differs from the adult in so many characters that no assumption can be made that it is of the same species. The new genus and species, which belongs to the family Sironidæ of the suborder Cyphophthalmi of the Order Opiliones, is here described.

Holosiro, new genus.

Tubercles containing the opening of stink glands situated dorsolaterally above coxæ II and III and projecting beyond the side margins of the body. Metatarsi about half as long as the tarsi. Tarsi of legs I and II simple but of legs III and IV (Fig. 1) flattened, subfoliaceous, two rayed, notched on the posterior margin and bearing a clavate sense organ above near the tip. Maxillary lobe of coxa I very broad, hence coxa I proper not contiguous with maxillary lobe of coxa II; terminal portion of pars manducatoria of the chelicera seen as a very minute area at the median margin of maxillary lobe of coxa I; tergite IX fused with sternites VIII and IX. In the adult state all dorsal abdominal tergites are fused into a great dorsal plate which not only completely covers the abdomen dorsally but extends laterally even on to the ventral side of the same.

Type species.—Holosiro acaroides, new species.

This genus is related to *Siro* Latreille and to *Parasiro* Hansen and Soerensen, probably more nearly to the first named, from which it differs in the shape and relationship of the maxillary lobe of the first coxa, in the character of the tarsal claws of legs III and IV and in the complete fusion of the abdominal tergites. It differs from *Parasiro* in the relative length of the tarsi to metatarsi, in the nature of the last two sternites and last tergite, in the tarsal claws and in some other respects.

The species is described as follows:

Holosiro acaroides, new species.

Adult female.—Body elongate, forming almost a perfect ellipse, and integument tuberculate. Cephalothorax almost completely fused with abdomen above; it is broadly and evenly rounded in front and slightly constricted behind the dorsal tubercles of the stink glands. These latter structures are cone-shaped, rounded at the tip and about as broad at their bases as they are high. Coxa I with large maxillary lobe which is fully as long as the coxa proper, inner margin almost straight and reaching median line, front margin concave, outer margin mildly convex and posterior margin, which is contiguous with the

anterior margin of maxillary lobe of coxa II for most of its length, almost straight. Coxa I proper is wedge-shaped internally. Maxillary lobe of coxa II somewhat comma-shaped, with the tail of the comma swollen on the inside. Coxa II proper a long band of chitin with almost parallel sides. Coxa III about as long as II but somewhat wedge-shaped. Coxa IV fully one-half as broad as long. Genital opening arched in front and partially covered behind by a projecting margin of chitin. Each coxa has several setæ; maxillary lobe of coxa I with a single seta which is situated at the outer posterior angle; maxillary lobe of coxa II on the left side with six setæ, on the right with seven.

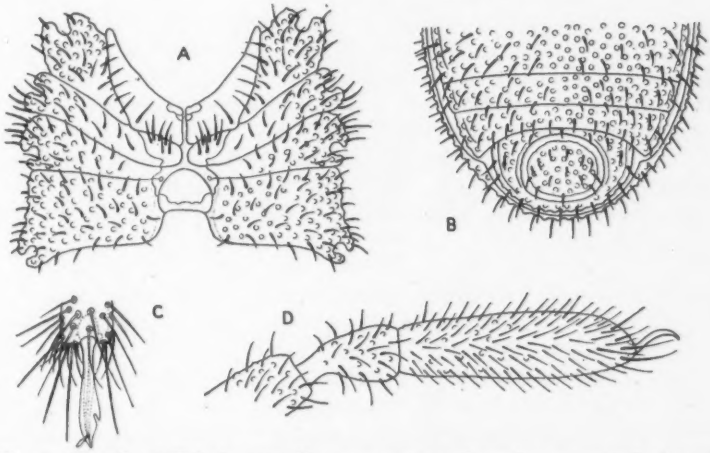


Fig. 1. Details of *Holosiro acaroides*, new genus and species; *a*, ventral view of cephalothorax; *b*, ventral view of tip of abdomen; *c*, dorsal view of tip of tarsus IV; *d*, side view of tarsus and metatarsus I.

Mouth-parts of the usual type of the family Sironidæ. Cheliceræ reaching to about the middle of the first coxæ; movable and fixed arms subequal and each with 6 to 7 teeth; pedipalps long and slender reaching to about the middle of tibiæ of first pair of legs; last segment about three-fourths as long as next to last and terminating in a simple claw.

Legs similar; first and last pairs subequal and slightly longer than the second and third pairs. Tarsi of legs I and II simple; of legs III and IV (Fig. 1) rather complicated and as described in the generic diagnosis of *Holosiro*. Metatarsi of all the legs somewhat curved, decidedly pedicellate and scarcely half as long as the tarsi. Tibia of leg I almost twice as long as metatarsus of leg II somewhat shorter, and of leg III and IV but little longer than metatarsus.

Abdomen of same width as cephalothorax; sparsely clothed with short setæ and more strongly tuberculate than the legs. Dorsal sclerites 1-8 fused, 9 united with ventral 8 and 9 to form a single sclerite which

includes the circular dorsal 10. Peritreme subtriangular and situated in a depression just lateral to hemispherical tubercle. Ovipositor, in repose, extending from near the front margin of sternite 6 almost to the genital opening. It ends distally in three finger-like processes and is remarkably similar in shape, structure and position to the ovipositor of the beetle mites.

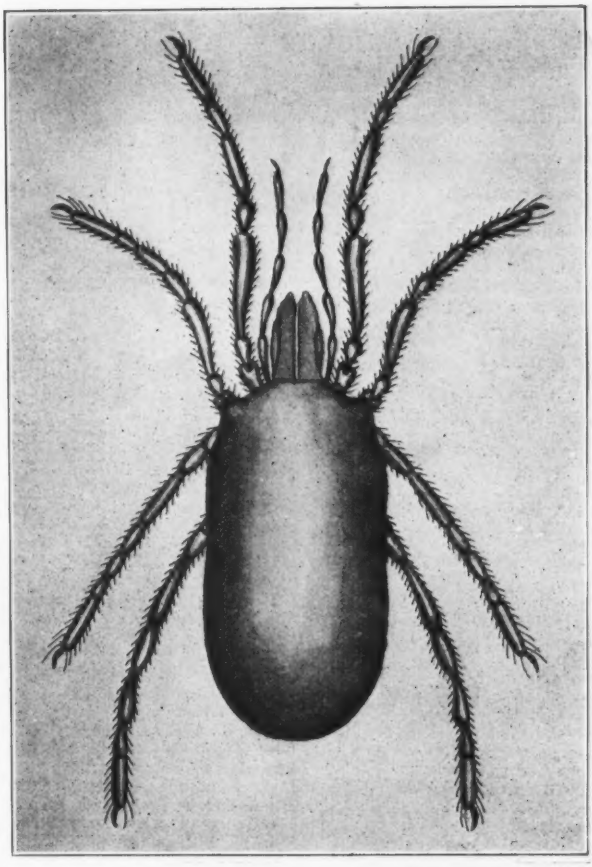
Length exclusive of chelicerae, 1.8 mm.; width, 0.85 mm.

Type locality.—Foothills of Coast Range Mountains, Benton County, Oregon.

Type.—Deposited at the United States National Museum.

Described from a single adult female, the holotype. An apparently immature specimen has the abdomen distinctly segmented above as already stated, but differs from the adult in so many particulars that there is no assurance that the two are of the same species. In this individual the ventral sclerites of the abdomen are as represented to exist in *Parasiro* and not of the *Siro* type as they are in the adult female. In this specimen, also, the tarsal claws of the last two pairs of legs are not expanded and have no sensory organ, but each has one or two teeth situated somewhat ventrally. It is also noted that in this apparently immature individual that the integument is pitted, not tuberculate, and that the maxillary lobes of coxæ I and II are quite differently shaped.

A note must be added in closing on the remarkable acarine affinities of this phalangid. First of all we here have a species in which all superficial indication of the segmentation of the abdomen dorsally is lost. Secondly, the number of segments in each of the legs and their arrangement is exactly the same as in certain mites, the Labidostomatidæ and the Opilioacaridæ for example. The number of segments (6) in the palpi, or pedipalps, is the same as in the mites of several families including the Gamasidæ and the Labiodostomatidæ. Further, the tubercles for the opening of the stink glands are in almost exactly the same position as are the tubercles of unknown function in *Labidostoma*. In regard to the stink glands of the family Sironidæ it is interesting to note the similarity of their structure and position to the lateral (excretory?) glands found in the mites of the family Tyroglyphidæ and in young of the Oribatoidea and in some instances also in the adults of the same superfamily, in which cases they open on tubercles as in the *Sironidæ*.



Holosiro acaroides, new genus and species.
Dorsal view of female, X 30.

H. E. Ewing

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